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Associate Editor: ARNOLD M. KUETHE, *Institute of the Aeronautical Sciences*

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JOURNAL OF THE
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Volume 5 JUNE, 1938 Number 8

On the Problem of Stress Distribution in Wide-Flanged Box-Beams

ERIC REISSNER, *Massachusetts Institute of Technology*

Presented at the Structures Session, Sixth Annual Meeting, I. Ae. S.
January 24, 1938

Introduction

THE structural analysis of monocoque and semi-monocoque structures, such as stressed skin wings, presents a number of complicated questions. One of these has to do with the fact that in a hollow wide-flanged box-beam, as such a wing may be considered, the stress distribution deviates appreciably from that in an ordinary "beam" even when its walls are so stiff that no local instabilities occur in the skin.

This paper contains a contribution to this problem which, because of reasons appearing presently, is often called the problem of "Shear Lag." In Section I, some general statements concerning this problem of stress distribution are discussed, some of which have been made previously by different authors. In Section II a quantitative theory of the stress distribution in rectangular *corrugated* box-beams is developed which is both simple and quite rigorous. It permits solving problems for corrugated beams, which, for beams consisting of flat sheets, are mathematically very complicated and have not so far been solved. In those cases where the analysis of the flat sheet-beam is feasible, the corresponding problem for the corrugated beam admits of a much simpler solution.

I. The Stresses and Deformations in Rectangular Box-Beams

In order to understand the problems which present themselves in the analysis of box-beams it seems best to consider a beam of rectangular section. It will be assumed that the beam is built in at one end and is free at the other (Fig. 1). It may be loaded in some way on one of the flanges. Furthermore, it may have stiffeners, longitudinals at the corners and in the middle, and a transverse stiffener (bulkhead) at the free end.

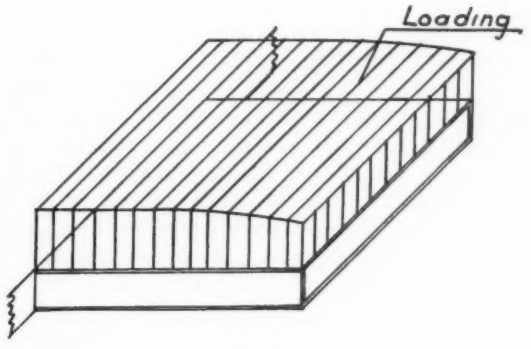


Fig. 1.

The first observation is that because of the resistance offered by the flange to bending normal to the x, y-plane the load is transmitted to the sidewebs and to the bulkhead which in its turn unloads itself to the sidewebs (Fig. 2). The forces acting on the sidewebs are balanced by the vertical shear in these members. To this vertical shear, which may be assumed to be constant across the web, there corresponds a horizontal shear. One considers the state of stress in the flanges set up by this horizontal shear (Fig. 3). According to the ordinary beam theory, this state of stress would be given by a simple law; in the case of a plane flange,

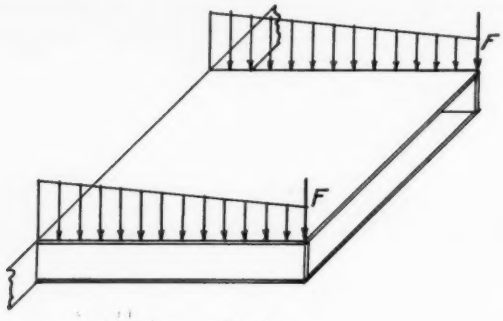
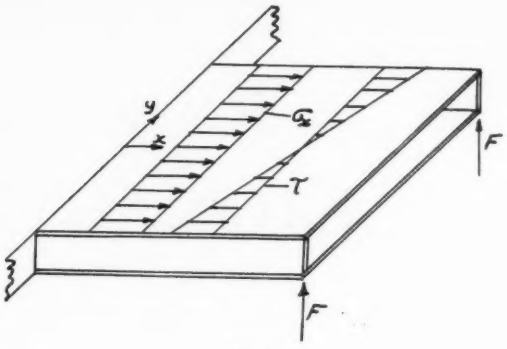


FIG. 2.



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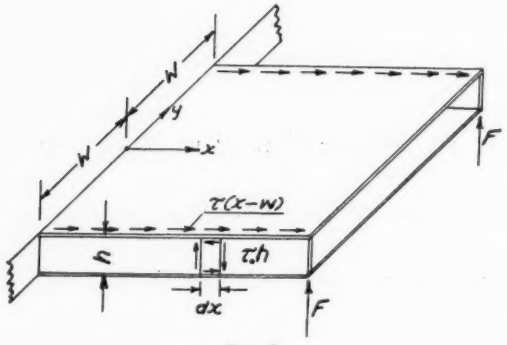

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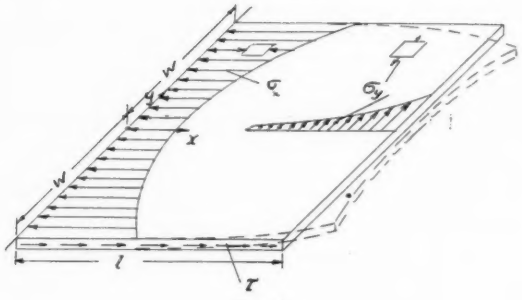


FIG. 5.

the normal stress would be constant across the sheet, and the shear stress would vary linearly (Fig. 4).

Actually, however, the state of stress is not given by a simple law. The edge shear forces cause a strain in the sheet which decreases from the edges toward the middle of the sheet. Consequently, the effective normal stress decreases toward the middle of the sheet (Fig. 5). Furthermore, for reasons of equilibrium, there are transverse normal stresses of the same order of magnitude as the longitudinal normal stresses in which one is primarily interested. This state of stress depends quantitatively on the forces acting, on the size of the sheet, and on the size and location of the stiffeners, longitudinal (stringers) as well as transverse (bulkheads). Some general observations concerning their influence can be made.

(1) *The influence of bulkheads.* The transverse stiffener is subjected to compression or tension along its axis and to bending in the plane of the sheet (Fig. 6). Its resistance to transverse forces tends to release the sheet from part of its transverse stresses. Its bending stiffness tends to equalize the displacements in the spanwise direction and, hence, to equalize the spanwise normal stress. Both effects are desirable and it is therefore concluded that the transverse stiffeners have a favorable influence on the effectiveness of the beam.[1] This fact has been known to designers but no quantitative theoretical results are known. The second part of this paper will show how these results can be obtained for the corrugated sheet-beam.

(2) *The influence of stringers.* It can be seen immediately that stringers in the corners are advantageous, since they increase the percentage of the material which works under maximum stress.

On the other hand, a stiffener in the middle of the sheet will make the beam less efficient for the reason that the more material concentrated in the middle of the sheet the higher is its resistance against being strained and consequently against being stressed. Thus the thicker such a stiffener is the less efficient it will be in carrying normal stresses which are transmitted to it from the sidewebs, mainly through the shear in the sheet between them (Fig. 7). This leads to the conclusion that, from the point of view of flange efficiency in bending, edge stiffeners should be strong and middle stiffeners as weak as their purpose (to make buckling impossible) permits. In contrast to this, a middle *spar* will increase the efficiency of the box-beam by splitting it off into two beams, each having half the width of the original beam.

Computations show that a stiffener of area A in the middle of a sheet of width w and thickness t reduces the normal stress in the stiffener to approximately the value which it would have if no stiffener were present the width of the sheet were increased to an amount $w + w'$ such that the additional sheet material $w't$ equals the area A of the stringer.

THE FUNDAMENTALS OF A THEORETICAL TREATMENT

For a quantitative treatment of the problem, it is necessary to study the plane state of stress which is produced in certain kinds of non-isotropic sheets. Call

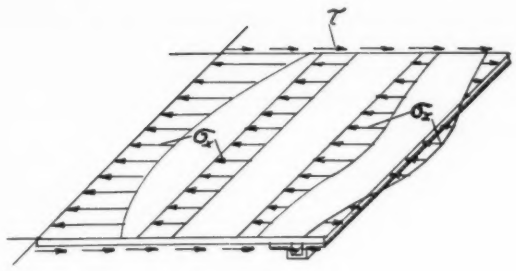


FIG. 6.

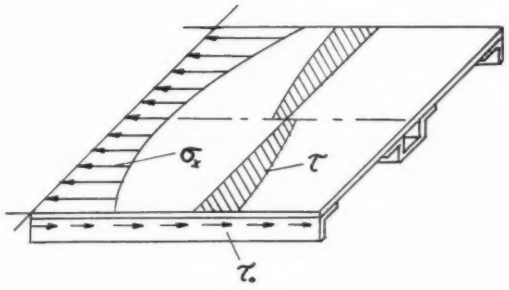


FIG. 7.

σ_x, σ_y, τ the stresses, u, v the displacements (Fig. 8.), E the modulus of elasticity of the material in spanwise direction, E^* the modulus of elasticity in the direction perpendicular to the spanwise direction, and ν and ν^* the corresponding Poisson's ratios. The problem consists of finding solutions of the following differential equations.

(1) The equilibrium equations for an element of area $dxdy$

$$(\partial\sigma_x/\partial x) + (\partial\tau/\partial y) = 0 \tag{1a}$$

$$(\partial\sigma_y/\partial y) + (\partial\tau/\partial x) = 0 \tag{1b}$$

(2) The stress-strain relations are

$$\epsilon_x \equiv \partial u/\partial x = (1/E)\,(\sigma_x - \nu\sigma_y) \tag{2a}$$

$$\epsilon_y \equiv \partial v/\partial y = (1/E^*)(\sigma_y - \nu^*\sigma_x) \tag{2b}$$

$$\gamma \equiv (\partial u/\partial y + (\partial v/\partial x) = (1/G)\tau \tag{2c}$$

From the theory of elasticity, a relation between the elastic constants is[2]

$$\nu^*E = \nu E^* \tag{3}$$

By using these two different moduli of elasticity in the two different directions, the case of non-isotropic sheet material such as corrugated or continuously stiffened material can be covered.

It is known that a solution of the system of Eqs. (1) and (2) can readily be found which satisfies all conditions along the juncture between the sidewebs and the sheet and between the longitudinal stiffeners and the sheet.[3] However, the solution is tedious, especially if there are several separate longitudinal stiffeners.

Furthermore, this known solution, given as early as 1899,[4] has the disadvantage of being suitable only for

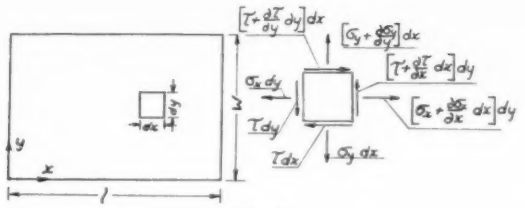


FIG. 8.

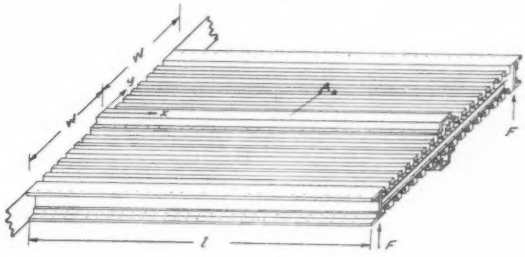


FIG. 9.

very special conditions along the lateral sections.[5] In this solution, the displacement u and the shear stress τ, rather than the displacements u and v, vanish at the built-in end. This condition could actually exist if the beam were so attached that complete freedom for end displacements in the transverse direction were possible.

At a free end, this solution demands a bulkhead absolutely rigid under the action of axial forces and nonresistant toward bending in the plane of the sheet. The applicability of the solution depends on whether these conditions are fulfilled or not, and if not, whether or not the deviations influence the result appreciably. There seems to be almost nothing quantitatively known about this, except for one example, which, however, does not cover the cases occurring in aeronautical structures.[6]

Advancement in this direction demands the solution of boundary-value problems which, though solvable, are mathematically quite complicated. There is also the possibility of studying the problem photoelastically. However, no attempts along this line are known to the author.

II. The Box-Beam with Corrugated Flanges

One may think that the complication of the problem is to some extent due to the existence of transverse normal stress in the sheet, and this leads to the consideration of a material which can take only very small stresses of this type, which, in turn, may finally be entirely neglected. Such a material makes the existence of transverse stiffeners *necessary* since the existing transverse forces have to be borne.

A material satisfying these conditions is a corrugated sheet considered as an orthotropic flat sheet, unable to carry stresses in the direction perpendicular to the waves (Fig. 9).

The result is that this problem, indeed, admits of a fairly simple solution, so general that all possible conditions along transverse sections can be satisfied.

If, in Eq. (1), it is assumed that

$$\sigma_y \equiv 0 \tag{4}$$

it follows that

$$\partial\tau/\partial x = 0 \text{ and } (\partial\sigma_x/\partial x) + (\partial\tau/\partial y) = 0 \tag{5}$$

From this, by integration,

$$\tau = f(y) \tag{6}$$

$$\sigma_x = -xf'(y) + g(y) \tag{7}$$

Here f and g are arbitrary functions to be determined by the boundary conditions.

The values for the displacements u and v are obtained from Eqs. (2). Eq. (2a) gives

$$u = (1/E)\int \sigma_x dx$$

$$u = (1/E)[-(x^2/2)\, f'(y) + xg(y) + h(y)] \tag{8}$$

where h is a third arbitrary function. From Eq. (2c),

$$(\partial v/\partial x) = (1/G)\,\tau - (\partial u/\partial y)$$

and, by introducing τ and u from Eqs. (6) and (8) and integrating,

$$v = (1/E)[(x^3/6)\, f''(y) - (x^2/2)g'(y) + xh'(y) + (E/G), xf(y) + k(y)] \tag{9}$$

where k is a fourth arbitrary function.

In order that this solution will also satisfy Eq. (2b), $E^*(\partial v/\partial y) = -\nu^*\sigma_x$, it is necesssary that

$$E^* = 0,\ \nu^* = 0 \tag{10}$$

The assumption that $E^* = 0$ is only an expression of the fact that there is no resistance against normal stresses in the direction perpendicular to the waves.

The result, Eqs. (6) to (9), shows that such a state of stress and strain is only possible with a stress varying linearly along x, *i.e.*, along the crests of the corrugations.

In other words, one is restricted to problems like pure bending, torsion with constant vertical shear, or bending with constant vertical shear between two adjacent transverse stiffeners.

This is, however, no real restriction, since a material of this sort actually has negligible bending resistance perpendicular to the waves and therefore continuously distributed loads are carried entirely by the bulkheads, which, in turn, act on the sidewebs as concentrated vertical loads between which the stress can only vary linearly.

An Example of the Use of the Solution

In order to illustrate the use of the general solution [Eqs. (6) to (9)], consider a box-beam built-in and free to bend at one end, the free end having transverse stiffeners rigid with respect to forces in the direction of their axes in the plane of the sheet. There may be longitudinal stiffeners in the corners and one in the middle of the sheet. Let the sheet width be $2w$, the length l, and consider the load concentrated at the free end (Fig. 9).

In terms of stresses and displacements, the boundary conditions for the positive side ($0<y<w$) of the flange sheet are†:

$$x = 0;\ u = 0, v = 0 \tag{11}$$

$$x = l;\ \sigma_x = 0, v = 0 \tag{12}$$

$$y = w;\ A(\partial\sigma_x/\partial x) - t\tau = t_0\tau_0 \tag{13}$$

$$y = 0;\ (1/2)\, A_0(\partial\sigma_x/\partial x) + t\tau = 0 \tag{14}$$

Eqs. (13) and (14) are the conditions of equilibrium for an element dx of the longitudinal stiffeners. Eqs. (11) yield immediately

$$h(y) = 0,\ k(y) = 0 \tag{15}$$

Eqs. (12) give

$$-lf'(y) + g(y) = 0 \tag{16}$$

$$(l^3/6)\, f''(y) - (l^2/2)\, g'(y) + (E/G)\, lf(y) = 0 \tag{17}$$

and by introducing g from Eq. (16) into (17)

$$f''(y) - (3E/G)\ (1/l^2)\, f(y) = 0 \tag{18}$$

The solution of Eq. (18) is

$$f(y) = c_1 \sinh \kappa y + c_2 \cosh \kappa y \tag{19}$$

where

$$\kappa = \sqrt{(3E/G)}\ (1/l) \tag{20}$$

and c_1 and c_2 are arbitrary constants to be determined by Eqs. (13) and (14).

Eqs. (19) and (16) give

$$\sigma_x = (l - x)\,\kappa\,(c_1 \cosh \kappa y + c_2 \sinh \kappa y) \tag{21}$$

$$\tau = c_1 \sinh \kappa y + c_2 \cosh \kappa y \tag{22}$$

Eq. (14) leads to

$$-(1/2)\, A_0 c_1 \kappa + tc_2 = 0 \tag{14a}$$

and hence Eq. (21) becomes

$$\sigma_x = c_1\kappa(l - x)(\cosh \kappa y + (\kappa A_0/2t) \sinh \kappa y) \tag{23}$$

From this expression the efficiency of the beam can be defined in different ways. One may take the relation between normal stress at the edge stringer and at the middle stringer

$$\eta = (\sigma_x)_{y=0}/(\sigma_x)_{y=w} \tag{24}$$

Calling the dimensionless quantities

$$\kappa w = \sqrt{3E/G}\, w/l = \mu,\ A_0/2tw = \gamma \tag{25}$$

† Here A denotes the area of the edge stiffener, A_0 the area of the middle stiffener, t the thickness of the sheet, and τ_0 the shear in the sidewebs.

one has

$$\eta = 1/(\cosh \mu + \gamma \mu \sinh \mu) \tag{26}$$

Eq. (26) indicates very clearly how the efficiency decreases with increasing value of the relation between stiffener area A_0 and sheet area $2tw$ (Fig. 10).

One may also derive an "effective width" $w_{eff.}$ of the flange defined by

$$w_{eff.} = \int_0^w \sigma_x dy/(\sigma_x)_{y=w} \tag{27}$$

which is, in this case, if $A_0 = 0$

$$w_{eff.} = w \ (\tanh \mu)/\mu \tag{28}$$

This can also be written

$$w_{eff.} = l\sqrt{(G/3E)} \tanh (\sqrt{(3E/G)}\ w/l) \tag{29}$$

Eq. 29 shows how wide the flange may be made, Its "effective width" is always smaller than

$$\text{Max. } (w_{eff.}) = l\sqrt{G/3E} \tag{30}$$

Eq. (30) shows the following: If the modulus E is increased without G being increased in the same proportion, then the effective width is diminished. This is, for instance, the case if one has many narrowly spaced stringers which may be considered as approximately uniformly distributed.

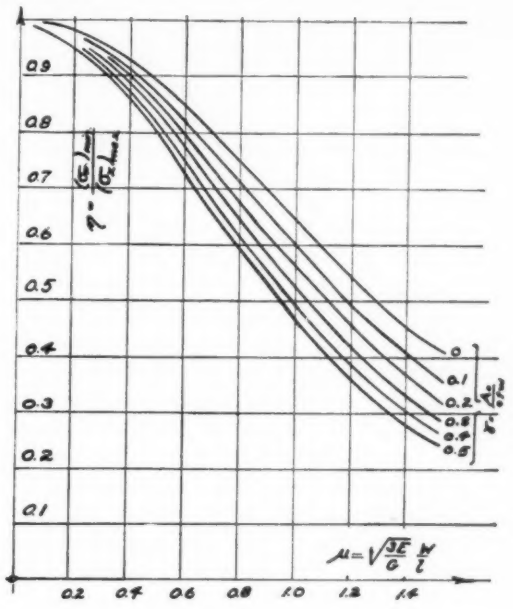


FIG. 10.

NOTES ON FURTHER PROBLEMS WHICH CAN BE SOLVED

In the same manner as in the preceding example, a series of related problems may be treated. One may consider (1) the same beam as that in the example with the exception that the bulkhead is also rigid as far as bending is concerned, (2) the elastic behavior of the transverse stiffener by considering it as an elastic rod or plate acted upon by forces in and perpendicular to its plane, or (3) a beam with a series of bulkheads and concentrated loadings at each of them.

The method of solution is always the same: The conditions along transverse sections of the beam furnish differential equations to determine the arbitrary functions in the general solution. Then the conditions along spanwise sections serve to determine the arbitrary constants which remain in the solution.

It is intended to give results of this sort at a later date.

REFERENCES

[1] For the problem of the twisting of moderately wide box-beams, a method for calculating the influence of end restraints has been given by Reissner, H., Zeitschr. f. Flugt. u. Motorluftschiffahrt, Bd. 17, pages 384–393, 1926. See also, Williams, D., British A.R.C., R. & M. 1761, May, 1936.

[2] Love, A. E. H., *Elasticity*, Cambridge University Press, page 97, 1906.

[3] von Kármán, Th., *Die Mittragende Breite*, Aug. Föppl Festschrift, pages 114–127, 1924.

[4] Lévy, M., Paris Comptes Rendus, Vol. 129, 1899.

[5] Reissner, E., Der Stahlbau, pages 206–208, 1934. For a different approach to this problem see Kuhn, P., N.A.C.A. Technical Report No. 608, 1937.

[6] Reissner, E., Zeitschr. f. Angew. Math. u. Mechanik, Bd. 15, pages 359–364, 1935.

Book Review

Meteorology as a Career; The Institute for Research, Chicago, 1938; 24 pages, $1.00.

This pamphlet presents in concise form the information customarily given in Weather Bureau stations to young men seeking this sort of information. Obviously the author has given much thought to this presentation. It is both comprehensive and accurate.

In fairness to a young man seeking a career in meteorology, stress should be placed on the following: the likelihood of an appointment is not great, there being relatively few openings and of these all but a small percentage are in the Weather Bureau; that meteorological work is emergency service—day and night—year in and year out; that recruits are placed where they are needed, sometimes far from home or some greatly desired location; and that but few workers in meteorology ever do independent forecasting.

The other side of the picture is: a good prospect for reasonable security; a type of work that presents a continuous procession of problems with which young men are given every facility to cope, and the satisfaction that in the long run he will have had a part in a useful public service. Men are encouraged to follow lines in which they show special aptitude, and every effort is made to place them where they will be best satisfied.

JAMES H. KIMBALL
U. S. Weather Bureau

Interference and Interaction from the Designer's Point of View

MICHAEL WATTER, *Glenn L. Martin Company*

Presented at the Aerodynamics, Session, Sixth Annual Meeting, I. Ae. S.
January 26, 1938

Summary

THIS paper treats certain phases of the turbulence problem generally defined as interference. Means of suppressing or minimizing interference are proposed and the geometry of design is analyzed in the light of the effect of interference phenomena. The results of a few wind-tunnel tests made in connection with this study are presented in order to show satisfactory experimental verification of the methods suggested.

Introduction

Turbulence plays an important part in the modern design. Although in its present state the theory of turbulence is beyond an immediate engineering usefulness, in a few years it is certain to become one of the important tools of applied science. The physical picture of turbulence, however, is beginning already to emerge partly through analytical studies and partly from experimental research.

It is the purpose of this paper to rationalize some phases of the problem from a point of view of semi-empirical interpretation. The limitations of the available experimental data make the approach more of a kinematical nature with only a partial extension into the aerodynamics of the phenomena. When, some three years ago, the first studies of this subject were started along its present form, the experimental data available were scarce and unreliable. Since then, however, certain substantiating tests were conducted which have given encouraging verification of the ideas and methods outlined in this paper.

Definitions and General Considerations

For the sake of clarity two distinct conditions of aerodynamic influences will be considered: namely, (1) interaction, which is defined as mutual adjustment of the airflow, and (2) interference proper, which is defined as a downstream effect of one body on another. In the case of interference it is assumed that the second body only is subjected to the effect of the changed airflow, the upstream effect being neglected.

Typical cases of interaction are wing-fuselage, fuselage-tail, and wing-nacelle behavior. Interferences include wing-tail, nacelle-tail, and seawing-tail behavior.

It is believed that the requirements of aerodynamic efficiency consist largely in maintaining as closely as possible the predominant flow by appropriate moulding of forms. This signifies, for instance, that if the part is an addition to the wing the two-dimensional flow must be given preference in the problem of streamlining. In all cases, however, it is necessary to reconcile the flows by a proper coordination of forms resulting in gradual and most efficient velocity gradient and smooth variation of the direction of streamlines. The question of flow divergence is clearly understood at the present time, but the maintenance of the predominant flow is being constantly violated.

Any form used in aircraft must be considered to be an airfoil. Since any streamline shape, properly inclined to the wind, generates lift with its attendant induced drag, it is important to guard against sudden changes in circulation. The expression of circulation $\int Vds$ points to two ways by which it may be controlled: (1) curvature to increase V, and (2) chord to increase ds. In the light of this interpretation it is best to coordinate forms so that their zero lift lines are parallel and aerodynamic centers coincide as closely as possible, since this results in the minimum vortex trail.

In streamlining, particular attention must be paid to regions of high speeds and in this respect considerations of local speeds are essential. Even with the best forms, however, the airflow in passing over them carries downstream a de-energized region called here the "Aerodynamic Shadow." The aerodynamic shadow is often called also the wake.

The extent and intensity of this region affects efficiency as well as stability and control.

Critical Regions

The formation and growth of the turbulent boundary layer may be caused by an unfavorable pressure gradient and the effect of curvature. The consideration of this fact makes it clear why regions of high velocity and abrupt changes in direction are most conducive to the formation of turbulence. On the other hand, since turbulence is also caused by friction, the surface roughness being a contributing factor, it is certain to appear in the regions well past the forward part of the form. To minimize these occurrences it is necessary to prevent undue expansion of the airstream by the use of proper fillets, enlargement of forms, and smoothness of surfaces.

It is, perhaps, justifiable to say that proper moulding of forward parts of wings, nacelles, fuselages, hulls,

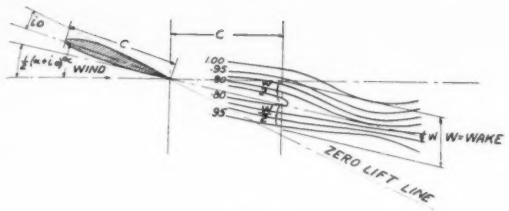


FIG. 1.

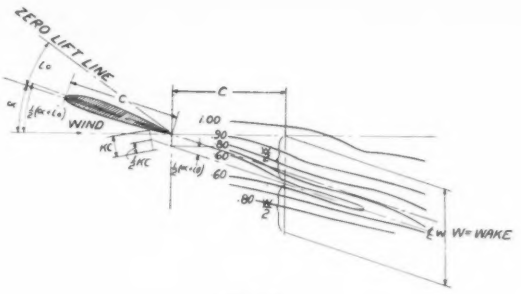


FIG. 2.

etc., is imperative to assure favorable interaction, while downstream regions are more closely associated with interference and turbulence proper. Even the best streamlined forms may result in airstream expansion with a consequent turbulence and high resistance. To minimize the danger of flow separation it is necessary to achieve a transition of profiles giving least rate of change in the direction of streamlines and velocity gradient.

AERODYNAMIC SHADOWS

Wing Shadow

The knowledge of the wing shadow is necessary for the selection of a suitable tail surface location to assure adequate stability and control as well as to safeguard against buffetting and flutter. It has been observed that the wing shadow bears a definite relationship to the attitude of the wing and the lift, but is not affected greatly by the airfoil. The shadow is least for angles of attack corresponding to the minimum drag, increasing progressively with the increase in profile drag.

Examination of available test data suggested the approximation of the wing shadow by means of a simple geometric construction. In at least four instances, specific verification tests indicated good agreement between the predicted and observed expanse and intensity of the wing wake. It was observed from available test data that the wing shadow's intensity is best considered at a normal plane at a distance of approximately one chord from the trailing edge. Past that section, which will be called the control plane, the intensity of the wake gradually decreases. By decrease of intensity of the wake is implied the decrease in the loss of dynamic pressure. Downstream, the dynamic pressure in the wake gradually approaches the dynamic pressure in the free airstream. The construction given in Fig. 1 applies to an unflapped wing or a wing equipped with flaps in which one can consider a single trailing edge. Fig. 2 gives the construction for split, Zap, Schrenk, or similar flaps. The construction is identical except that in the case shown in Fig. 2 the trailing edge point is replaced by a midpoint of the line joining the wing and flap trailing edges.

To understand the construction it will suffice to observe that the wake must be expected to follow along the downwash of the wing. It was found that a sufficiently close approximation of the center of the wake is obtained by assuming it to lie on a line bisecting the absolute angle of attack, *i.e.*, the angle measured between the relative wind and zero lift angle. The zero lift line in question applies to the specific condition for which the wake is being determined and hence must be known or approximated, for instance, for various flap openings. The effective width of the wake, measured at the control plane along the line perpendicular to the relative wind, can be taken approximately as twice the distance between the relative wind direction and the line bisecting the absolute angle of attack. The direction of the relative wind is drawn horizontal and passing through the trailing edge of the wing.

To approximate the average dynamic pressure within the wake one can make use of the formula derived by Betz for the purpose of determining the profile drag of a wing. In this case the operation is reversed assuming that the profile drag is a known quantity.

$$D_0 = l\int (g_0 - g)dy + \frac{\rho}{2} l \int_{-\infty}^{+\infty} (V_0^2 - V^2)dy$$

This is Eq. (3) of Schrenk's paper *Measurement of Profile Drag on an Airplane in Flight by the Momentum Method*, where he states: "It will be shown later that this (first) integral plays numerically the most important part, while that of the second member is gradually reduced with increasing distance between the after control plane and the drag body to be tested." For the purpose of this paper it is sufficiently close to neglect the second integral and to replace the total pressures in the first integral by the dynamic pressures in the fluid vein. Thus, designating the area of the wake at the control plane by A and using mean dynamic pressures one may write $D_0 = A(q_0 - q)$ where $q_0 = \rho V_0^2/2$ is the dynamic pressure outside the wake while $q = \rho(V_0 - v_1)^2/2$ the mean dynamic pressure of the wake at the control plane v_1 being the total loss of speed in the wake.

Substituting

$$D_0 = A\left\{\frac{1}{2}\rho V_0^2 - \frac{1}{2}\rho(V_0 - v_1)^2\right\} = Av_1\rho\left(V_0 - \frac{v_1}{2}\right)$$

It is interesting to observe that the same expression can be obtained from momentum theorem consideration following Froude's derivation for the propeller thrust. Considering one foot of span and using the standard expression for the drag coefficient one has:

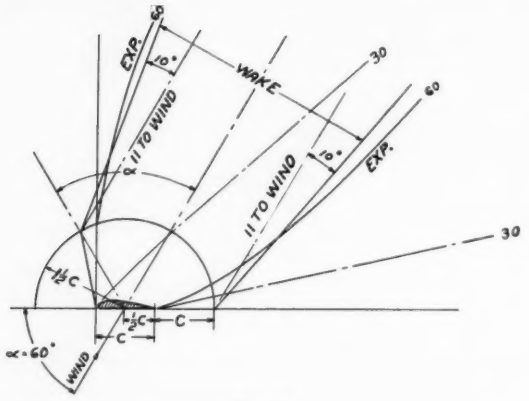


FIG. 3.

$$C_{d_0} c q_0 = w(q_0 - q)$$

where c is the chord and w the width of the wake. Solving for q/q_0 one obtains

$$q/q_0 = 1 - (C_{d_0} c/w)$$

It is important to fix the fact that C_{d_0} is the profile-drag coefficient. To obtain the dynamic pressure at any point past the control plane the calculated value must be corrected using a coefficient from Fig. 4. This coefficient depends both on the magnitude of the mean dynamic pressure at the control plane and the location of the section being investigated. Available tests indicate satisfactory agreement between the q/q_0 ratio observed and calculated from Fig. 4.

Figs. 1 and 2 applied to the unstalled condition of the wing. For stalled condition the construction is modified because of the highly turbulent condition of the wake and its consequent rapid expansion. Fig. 3, which is self-explanatory, gives the construction for the case of a stalled wing. It is based on data given in N.A.C.A. Technical Memorandum No. 632 and gives surprisingly accurate boundaries as compared with those experimentally obtained.

Nacelle and Fuselage Shadow

Several published articles have indicated that the presence of wing-engine nacelles, particularly in the case of a low wing design, is detrimental to stability. Pitching moment curves obtained on the model with and without nacelles indicate that the loss in stability is considerably greater than the amount of the unstable moment due to the nacelle proper. Attempts were made to explain this phenomenon by unfavorable interaction called the "interference burble." In a number of specific tests, however, conducted by The Glenn L. Martin Company, it was definitely established that by applying the simple explanation of the aerodynamic shadow, the loss in stability can be anticipated, controlled, and satisfactorily accounted for without resort to more involved phenomena. It is pertinent that in all the instances investigated by this method it was not

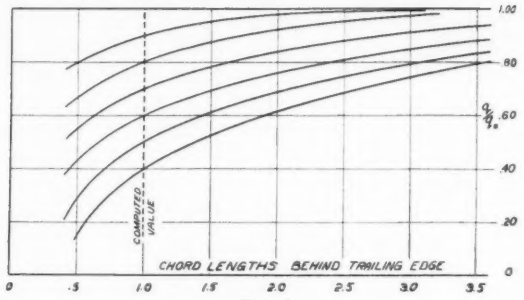


FIG. 4.

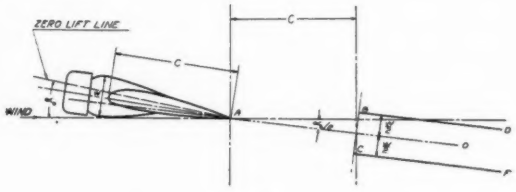


FIG. 5.

essential to assume any change in downwash, nor was such change indicated by lift curves obtained.

The nacelle shadow appears to be a jet or a cylinder whose diameter is equal to the diameter of the nacelle. Its center line is assumed to coincide with the center line of the wing shadow, *i.e.*, along the line bisecting the absolute angle of attack of the wing at the nacelle. The control plane is still taken at a distance of one chord from the trailing edge of the wing and the effective value of the dynamic pressure of the jet is calculated from the known drag of the nacelle and the momentum loss. The variation of q downstream from the control plane is taken as before, from Fig. 4. For the control plane the momentum equation can be written: $D = C_d A \rho V_0^2/2 = A v_1 \rho [V_0 - (v_1/2)]$ as before $q/q_0 = 1 - C_d$, where C_d is the drag coefficient of the nacelle referred to its own cross-sectional area, A.

This construction of the nacelle shadow, shown in Fig. 5, was suggested by analysis of a few tests, but since then, more checks were obtained from wind-tunnel tests on complete airplane models. Two of these tests were indirect, while in several other instances the turbulent wake was obtained by means of a pitot tube mounted in the region of the tail surfaces.

Since the drag of a nacelle is often appreciable, the loss of the dynamic pressure within the shadow leads to a considerable modification of the tail behavior. The effect of such a de-energized jet may be twofold: (1) loss of lift due to decrease in dynamic pressure, and (2) change in effective tail-section curvature due to proximity of the jet. The latter is due to the redistribution of velocities and hence a change in the circulation around the tail-airfoil section. The effect of the nacelle shadow on stability will be discussed later.

The fuselage shadow is obtained similarly to the nacelle shadow, but the construction in all standard cases, is of little interest. It is sufficient to assume

that the cross-section of the de-energized jet is equal to the major cross-section of the fuselage.

INTERACTION

Fillets

Despite numerous discussions, one cannot help but feel that the protagonists and the antagonists of fillets are somewhat obscuring the problems of airflow with the flow of discussion.

For the purpose of illustration a brief description of the type of fillet which will conform to the principles advanced in the section on "Critical Regions" is given here for the case of a low wing monoplane with the wing set at some angle to the center line of what may be considered a well streamlined body. Theory permits a very satisfactory evaluation of the characteristics of wing-fuselage combination, but resort will be made to a semi-empirical procedure which is more expeditious for engineering purposes. In most cases of fillet design it will be found that tenets for fairing for the predominant flow can be complied with but partially. It is more important in this instance to "reconcile the flows by a proper coordination of forms resulting in gradual and most efficient velocity gradient and smooth variation of the direction of streamlines."

To retain the wing flow as close to the root as possible it is necessary to form the inboard fillet portion so as to have it lie in the vertical plane (neglecting the effect of dihedral). Hence, a vertical plane is drawn tangent to the body. On this plane it is possible to draw an outline, geometrically similar to the body and having its quarter chord point coinciding with that of the wing. This outline and its position give the desired parallelism of the zero lift lines. It is necessary now to assume a gradual and smooth variation of the inclination of the zero lift line of the fillet sections. Establishing a set of lines giving gradual and continuous expansion of the airfoil into the shape of the inboard contour, it is possible to arrive at a set of contours of the desired fillet. The fillet obtained need not be large, but it will possess the following essential qualities, incorporated by virtue of the construction adopted: (a) Substantially vertical inner surface. (b) Uniform outline in side view having zero line parallel to that of the body and obtained *by proper modification of the leading edge* as well as the trailing edge portions. (c) Gradual and smooth variation of curvatures in all planes.

This type of fillet was applied to a body of a very large cross-section in combination with the 230-series airfoil. The tests proved that there was a favorable wing-fuselage drag interaction with no loss in the maximum lift compared to that of the wing alone. The Reynolds Number of the tests was close to 1,000,000. The same reasoning and procedure were applied for fillets of two high-wing and one mid-wing designs and the tests showed highly satisfactory confirmation of the anticipated results. Fig. 6 gives schematically the essential feature of such a fillet design. However, whether the method will be generally successful cannot be stated without further numerous tests.

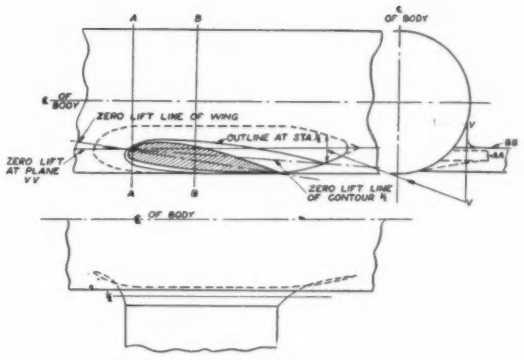


FIG. 6.

Fairings

Fairing of a normal wing-engine nacelle offers an excellent illustration for the necessity of favoring the principal two-dimensional flow due to the wing. The normal type of a nacelle shape consists of a three dimensional streamlined form being placed partly within the wing. The fact that the presence of the wing implies a two dimensional flow appears to have been almost generally overlooked. It is obvious, however, that the attempt to superimpose a three dimensional flow on the two dimensional wing flow must result in unfavorable interaction. These considerations prompted the adoption of a nacelle shape named the "beaver tail" type. As the name implies, instead of tapering to a point, this shape has a broad after portion.

One may class the fairing of the strut attachment to the wing in the same general group when the enclosed angle is fairly acute.

The effect of the body on the tail surfaces is somewhat more complex than a strict case of interaction and partly includes the effect of interference. Attention was first drawn to this problem by peculiarities obtained in break-down tests of a certain model when tests of the isolated body and tail were compared to the results of tests of body-tail and body-wing-tail combinations.

The body-tail interaction and interference is complicated by the fact that the direction of the airflow at the tail is affected by the resultant flow from body and wing. From a limited number of tests it would seem that it is sufficiently accurate, however, to assume that the airflow around the body is mainly controlled by the wing. This, of course, simply implies that the body does not undergo the same variation in effective angle of attack, but is subjected to the airflow following more closely the changes of the downwash. This is true only to the extent to which the mass of air controlled by the wing predominates the mass of air affected by the body. Considering the case of a large flying boat, and that of

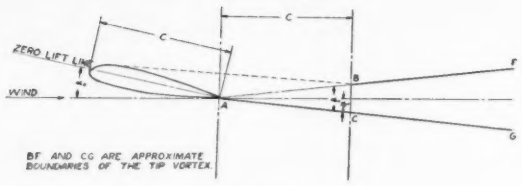


FIG. 7.

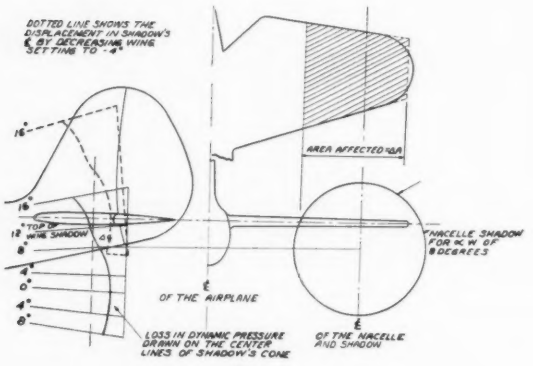

DOTTED LINE SHOWS THE DISPLACEMENT IN SHADOW'S & BY DECREASING WING SETTING TO -4°
AREA AFFECTED ΔA
NACELLE SHADOW FOR ∝ W OF 8 DEGREES
OF THE AIRPLANE
LOSS IN DYNAMIC PRESSURE DRAWN ON THE CENTER LINES OF SHADOW'S CONE
OF THE NACELLE AND SHADOW

FIG. 8.

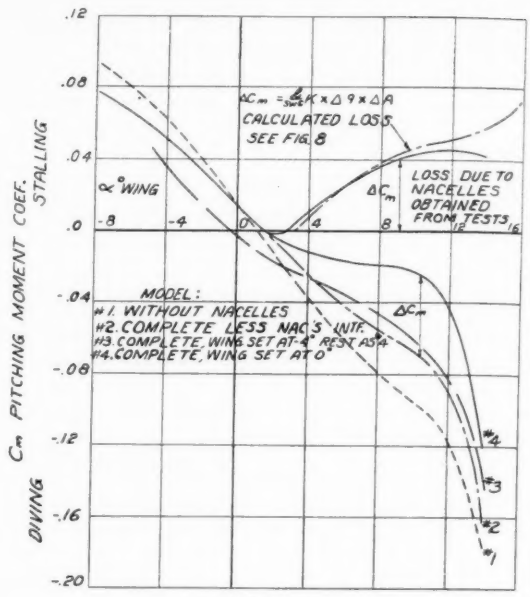

Cm PITCHING MOMENT COEF.
STALLING
DIVING
ΔCm = K x Δq x ΔA
CALCULATED LOSS SEE FIG. 8
∝° WING
LOSS DUE TO NACELLES OBTAINED FROM TESTS
MODEL:
#1. WITHOUT NACELLES
#2. COMPLETE LESS NAC'S UNIT.
#3. COMPLETE, WING SET AT -4° REST AS #4
#4. COMPLETE, WING SET AT 0°

FIG. 9.

sponsons, it is more logical to assume that the body influence will be considerably more pronounced in the former case. It is believed that even this problem is susceptible of a simplified analysis and it is hoped that later research will enable one to establish means to approximate the resultant flow.

The reference to sponsons suggests a mention of tip vortices and their effect on the location of horizontal tail surfaces. In this respect also it is important to evaluate both the direction and expansion of the tip vortex. For the purpose of avoidance of the disturbed region it is sufficient to assume the construction of the vortex cone given in Fig. 7.

STABILITY

The importance of aerodynamic shadows on stability was mentioned in connection with wing-engine nacelle effect. The preceding paragraphs indicated the method for determination of the effective q/q_0 in the wing or the nacelle shadow. In studies of the effect of the wing-nacelle shadow it is best to obtain an average q_0 in the de-energized jet due to the nacelle. It can be assumed, approximately, that

$C_{d_0}c2rq_0 + C_d\pi r^2 q = \pi r^2 v_1 \rho\left(V_0 - \frac{v_1}{2}\right)$, where r is the nacelle radius. Setting $C_{d_0}2c/\pi r + C_d = C_d'$ and solving for q/q_0, $\frac{q}{q_0} = 1 - C_d' = 1 - C_{d_0}\frac{2c}{\pi r} - C_d$.

This must be considered as the first approximation but will generally suffice for a preliminary estimate.

To substantiate the hypotheses advanced in this paper regarding the effect of aerodynamic shadows the first preliminary tests were as follows:

A twin-engined low wing monoplane design was selected because of its poor longitudinal stability indicated by a definite flat portion in the pitching moment curve obtained in the wind tunnel. The wind-tunnel report contained individual characteristics of the component parts such as wing alone, body alone, wing and nacelles, body and tail, wing, nacelles, and body.

To estimate the loss in tail efficiency, the nacelle shadow was drawn and the tail area intercepted by it was obtained graphically. For simplicity the change of effective curvature of the tail moment was taken as proportional to the product of area affected times the loss in dynamic pressure. The loss in moment coefficient and the product $(l/S_w c)\,\Delta A \cdot \Delta q$ are plotted on Fig. 9. In this expression l is the tail arm, S_w the wing area, c the mean aerodynamic chord, ΔA the tail area affected by the nacelle shadow and Δq the calculated loss in dynamic pressure.

The zero point, indicating the angle at which the nacelle shadow begins to influence the tail, is in a very good agreement with tests. The discrepancy appears at an angle of attack of about 13° when the anticipated losses, due to the nacelles, are larger than indicated by the tests. Since in obtaining the losses in pitching moment, only the effect of the nacelle shadow was considered it is obvious that at angles of attack greater than 12° other interference was present. By observing the wing shadow this explanation is confirmed. Fig. 8 shows that the wing shadow begins to strike the tail at about the observed angle of attack and its influence increases with its further increase.

The effect of the wing shadow on the pitching moment curve was shown by changing the wing setting from 0° to −4°. As anticipated, the flat portion in the moment curve disappeared completely. This test, quite interesting in itself, also pointed out the encouraging fact that, in general, it was not essential to place tail surfaces

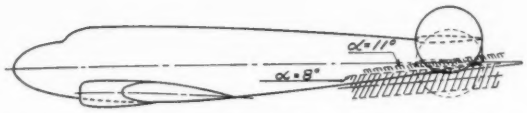


FIG. 10. Model A. High and low tail positions and predicted nacelle wake.

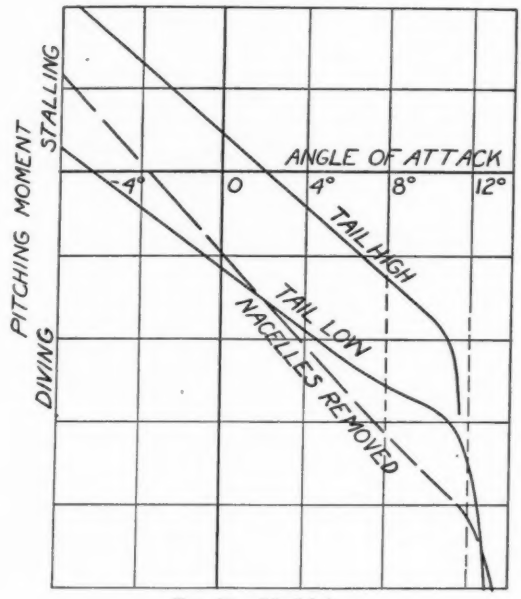


FIG. 11. Model A.

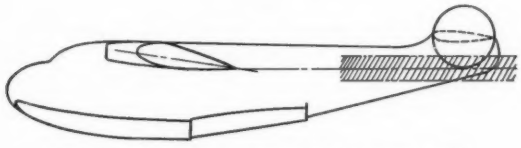


FIG. 12. Model B. Nacelle shadow near stall.

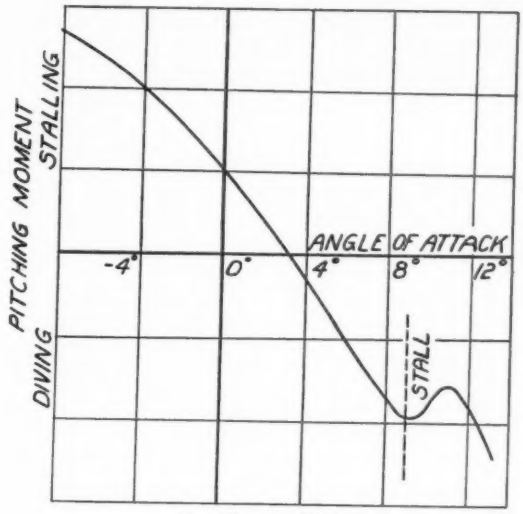


FIG. 13. Model B.

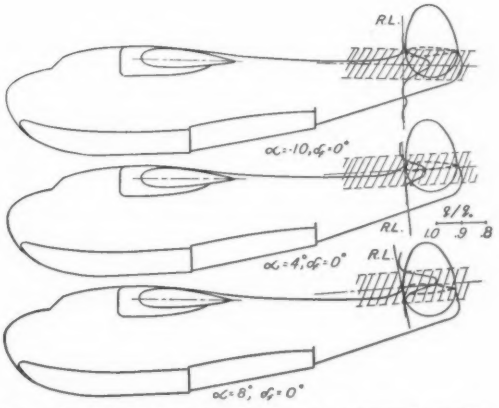


FIG. 14. Model C. Predicted and measured nacelle wake.

in a high position, but that in a suitably coordinated design a low tail position can be equally efficient.

With the understanding of the effect of the nacelle shadow on stability, the tail location in the next design was selected in such a way as to assure that the tail efficiency would not be impaired for the range of flying attitudes. The wind-tunnel tests resulted in a complete confirmation of the sound location of the tail surfaces as can be observed by a perfect pitching moment curve. To prove that this regularity was not accidental the tail surfaces were moved within the shadow. Figs. 10 and 11 indicate that, as was to be expected from the study of the nacelle shadow, the pitching moment curve should, and did, flatten out at angles of attack above about 8°. In the case of Model "B" the tail surfaces were again located outside the boundaries of the nacelle shadow. Fig. 12 shows the latter at an angle of attack close to that of stall. Since, with the increase in angle of attack the nacelle and wing shadows move upwards, it is obvious that it was expected to have the tail efficiency unimpaired by the de-energized wake. Fig. 13, giving the pitching moment curve obtained for this model, fully confirms this expectation.

To increase the quantitative value of the tests it was thought essential to obtain the actual outline of the wing and nacelle shadows. This was particularly important in the latter case since no published information has been found on the width of the wake due to the nacelles.

The tests were conducted in the N.A.C.A. 7 × 10 ft. Atmospheric Tunnel. A pitot tube mounted in the plane of the nacelle and located at the region of the tail surfaces was used for the exploration. The data obtained is reproduced here in Figs. 14, 15, 17, 18, 19, 21, and 23. In these figures the cross-hatched area represents the predicted wake, while the full lines give the q/q_0 ratio as actually obtained. This ratio was plotted from a reference line, designated on the figures by the abbreviation R.L. At the reference line $q/q_0 = 1.0$ and points of the full line to the right of it indicate the magnitude of loss in the ratio of q/q_0. The agreement of expanse, direction, and average intensity was found

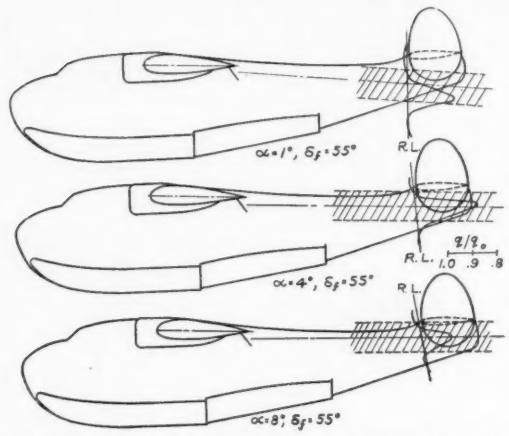


FIG. 15. Model C. Predicted and measured nacelle wake.

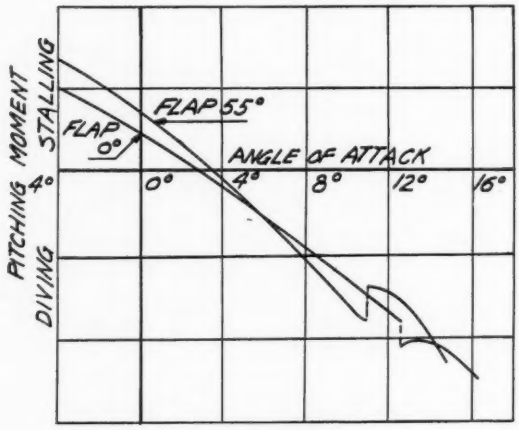


FIG. 16. Model C.

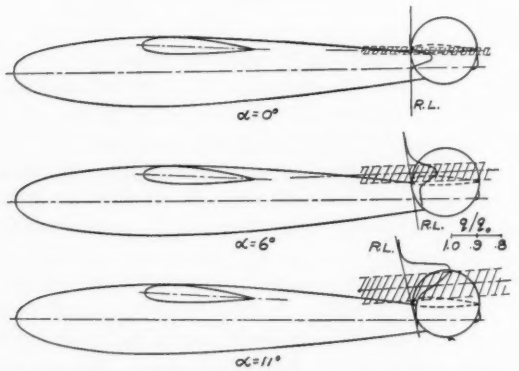


FIG. 17. Model D. Predicted and measured wing wake.

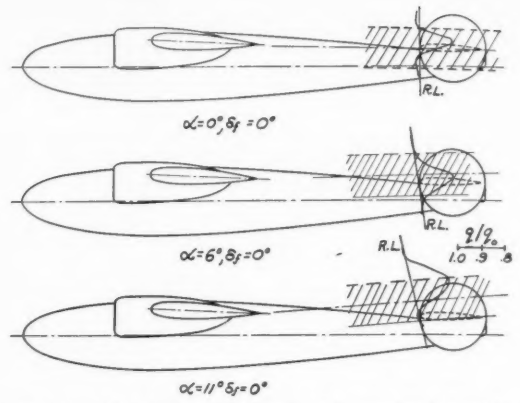


FIG. 18. Model D. Predicted and measured nacelle wake.

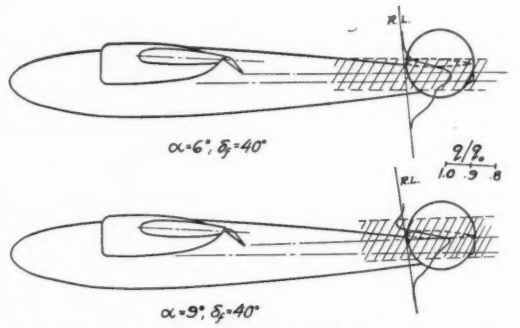


FIG. 19. Model D. Predicted and measured nacelle wake.

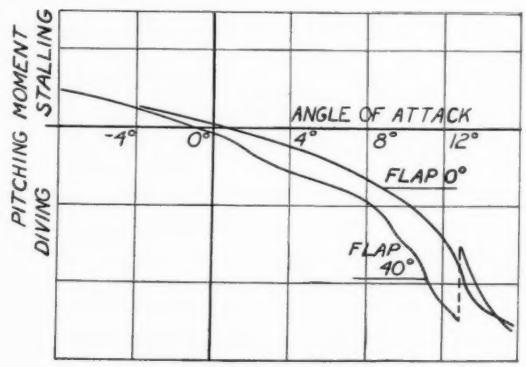


FIG. 20. Model D.

to be very good. Certain peculiarities can be observed in the form of double peaks, and this feature will be analyzed in the near future.

It will be observed that in both Models "C" and "D," the tail surfaces were located within the boundaries of the nacelle shadow. Model "C," however, shows a pitching-moment curve without any irregularities, while in the case of Model "D," the curve is irregular and the slope is less. The explanation of this lies in the fact that the area and arm of the horizontal tail surfaces were, in the case of Model "D," proportioned on the basis of the total unstable moment without due regard to the effect of the nacelle shadow. Because of the relative size of the nacelles and the wing, the effect of the nacelle shadow in the case of Model "D" is considerably accentuated as compared to the effect present on Model "C." Because of this fact, the size of the tail surfaces of Model "D" must be considerably larger than that of Model "C."

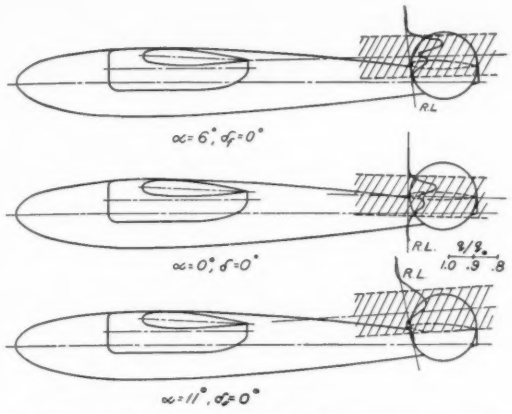


FIG. 21. Model D-1. Predicted and measured nacelle wake.

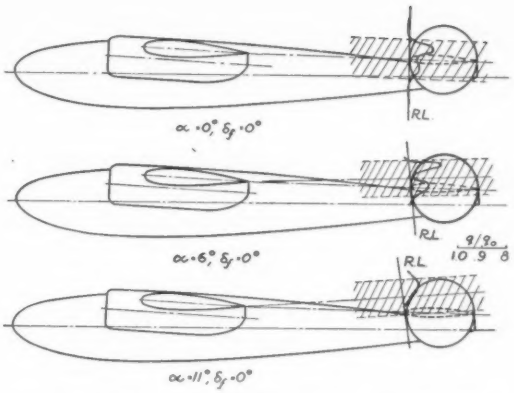


FIG. 23. Model D-2. Predicted and measured nacelle wake.

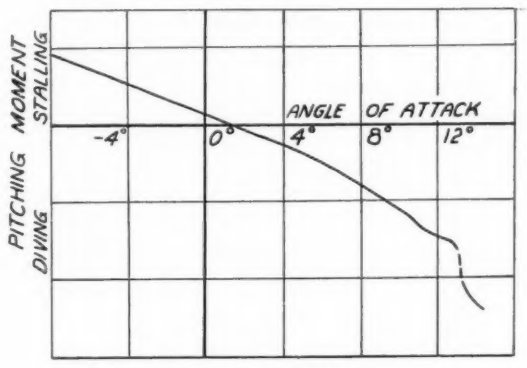


FIG. 22. Model D-1.

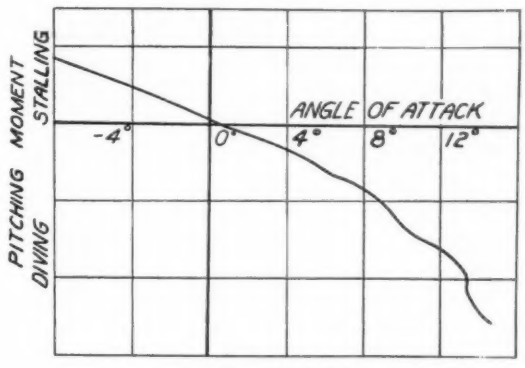


FIG. 24. Model D-2.

Modifications of nacelle shape and its angular setting on the wing had a negligible effect, as it can be observed from Figs. 21, 22, 23, and 24.

From the observed effects of the nacelle shadow, generally speaking, the only logical conclusion is to consider the region indicated by the boundaries of the nacelle shadow as a definite danger zone to be avoided in selecting a suitable location for the tail surfaces of a new design. In special cases, however, this may be impossible, and in such instances the wing setting and tail size and arm must be coordinated to give the desired regularity and slope of the pitching moment curve.

The means of approximating the intensities and regions of turbulent airflow enable one to estimate the frequency and intensity of disturbances to which various parts of the airplane may be subjected. The problems of vibration, flutter, and buffeting are dependent upon the knowledge of the turbulent shadow, and even an approximate evaluation such as is offered here is of assistance.

REFERENCES

[1] Diehl, W. S., *Engineering Aerodynamics* (Revised Edition), The Ronald Press Company, New York, 1936.

[2] Tietjens, O. G., *Applied Hydro and Aeromechanics*, McGraw-Hill Book Company, New York, 1934.

[3] ———————, *Fundamentals of Hydro and Aeromechanics*, McGraw-Hill Book Company, New York, 1934.

[4] Wallace, R., *Investigation of Full-Scale Split Trailing Edge Wing Flaps with Various Chords and Hinge Locations*, N.A.C.A. Technical Report No. 539.

[5] White, J. A., and Hood, M. J., *Wing-Fuselage Interference Tail Buffeting, and Airflow about the Tail of a Low Wing Monoplane*, N.A.C.A. Technical Report No. 482.

[6] Klein, A. L., *Effect of Fillets on Wing-Fuselage Interference* A.S.M.E. Transactions, January, 1934.

[7] Betz, A., *A Method for the Direct Determination of Wing-Section Drag*, N.A.C.A. Technical Memorandum No. 337.

[8] Schrenk, M., *Measurement of Profile Drag on an Airplane in Flight by the Momentum Method*, N.A.C.A. Technical Memoranda Nos. 557 and 558.

[9] Petersohn, E., *Downwash Measurements Behind Wings with Detached Flow*, N.A.C.A. Technical Memorandum No. 632.

[10] *Measurement of Profile Drag by the Pitot-Traverse Method*, British A.R.C., R. & M. No. 1688, January, 1936.

[11] Glauert, H., *Influence of a Uniform Jet on the Lift of an Airfoil*, British A.R.C., R. & M. No. 1602.

[12] Hirst, D. M., and Hartshorn, A. S., *Efficiency of Tail Plane Behind Wing of R.A.F., 34 Section*, British A.R.C., R. & M. No. 1478, April, 1932.

[13] Fage, A., *On the Drag of an Airfoil for Two-Dimensional Flow*, British A.R.C., R. & M. No. 1015, November, 1925.

[14] Bryant, L. W., and Williams, D. H., *An Investigation of the Flow of Air Around an Aerofoil of Infinite Span*, British A.R.C., R. & M. No. 989, February, 1924.

A Study of Available Flap Data

RICHARD C. MOLLOY, *United Aircraft Corporation*

(Received March 28, 1938)

Summary

AN ANALYSIS of published data on flaps indicates that in spite of the number of tests made, the results of such tests are by no means complete or consistent. These inconsistencies can probably be charged to slight changes in flap design for the same type of flap, to differences in testing technique, and to the effects of scale and turbulence. In the case of $\Delta C_{L_{max.}}$ for split flaps, and for other types also, this characteristic changes with airfoil thickness, camber, and camber position, in addition to changing with the factors already mentioned.

The assumption that $\Delta C_{L_{max.}}$ is independent of Reynolds Number may be reasonable for split flaps. It also appears to be true for other types of flaps. However, the fact that a few tests of split flaps show $\Delta C_{L_{max.}}$ to vary by as much as 20 percent as the Reynolds Number is changed, indicates that this assumption requires additional investigation. More accurate comparative test data are needed to settle the question of the superiority of one type of flap over another. Additional tests may, and probably will, indicate a different order of flap performance than that shown in Figs. 6 and 7 for an average of the data. More data on slotted flaps would be particularly useful.

Characteristics other than $C_{L_{max.}}$ should be investigated more fully, in order that the designer may weigh those factors which are important in the choice of a type of flap to aid in take-off, as well as in landing. The effects of wing-design variables on the aerodynamic characteristics of wing-flap combinations need further investigation.

Introduction

It is well known that the aeronautical industry is indebted, in the main, to the National Advisory Committee for Aeronautics and the British Aeronautical Research Committee for the many reports dealing with wing flaps which are available in the English language. The advent of high wing loadings has made such information of considerable importance to the designer, for the landing and take-off problems associated with heavily loaded aircraft may be partially solved by the use of certain types of flaps.

That these data have been extremely useful to the airplane designer is unquestioned. It was felt, however, that their value might be enhanced if the information on the various types of flaps could really be correlated. If the effects of the many variables affecting flap performance could be isolated, then presumably tests on the same type could be summarized, and a fair basis of comparison might be established for all those commonly used. (Fig. 1.)

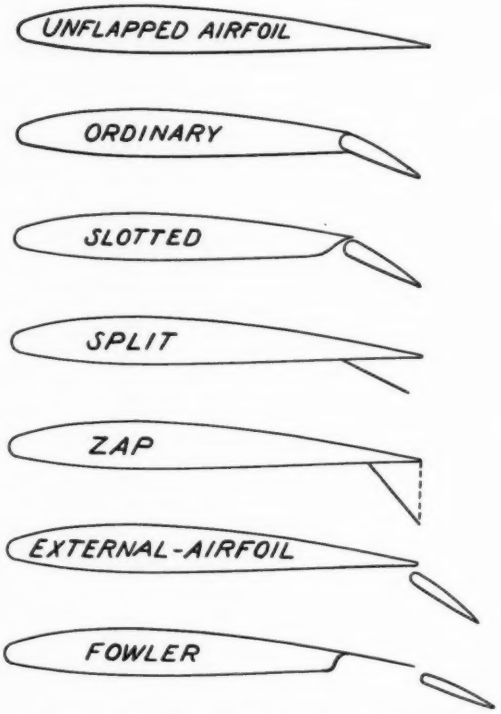


FIG. 1. Common types of wing-flap combinations.

Such an analysis has been attempted for available flap data, and while it is by no means exhaustive, certain opinions have been formed relative to the correlation of such data. In addition to the wing-flap maximum lift coefficient, other aerodynamic characteristics such as center of pressure travel, angle of attack at maximum lift, maximum lift-drag ratio, and lift-drag ratio near maximum lift were investigated. Only by a study of all factors affecting flap performance can the designer determine the most suitable flap for a particular airplane design, and those selected for analysis were felt to be of greatest importance.

Increment in Maximum Lift Coefficient

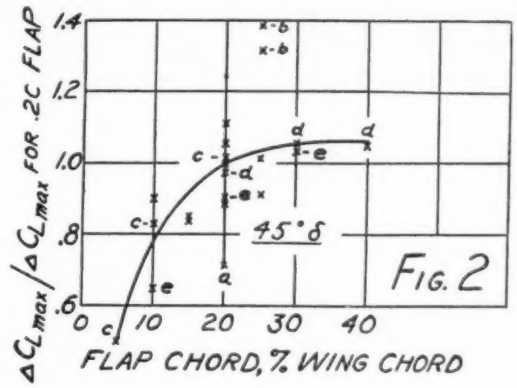
It has been stated that for split flaps the increment in maximum lift coefficient due to the use of a flap,

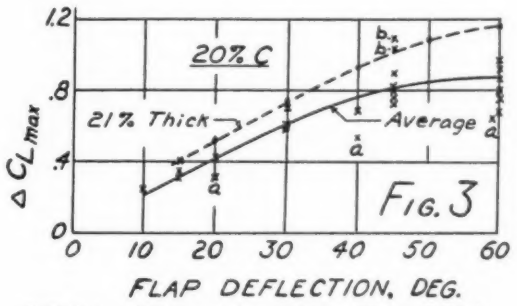
$\Delta C_{L_{max.}}$, "may be considered to be independent of Reynolds Number."[1] Lacking adequate information for other types of flaps it seems necessary to assume that this may also be true for all those considered here. On this assumption it would be convenient in making estimates of wing-flap performance, to have charts showing the variation of $\Delta C_{L_{max.}}$ with flap deflection and chord, so that the lift-coefficient increments as determined therefrom could be added to the full scale $C_{L_{max.}}$ for the unflapped wing. This latter value could be ascertained from data given in a recently published report,[2] which deals in an excellent manner with the problem of estimating wing aerodynamic characteristics from airfoil *section* characteristics at any Reynolds Number.

To prepare these charts, test data were generally taken directly from the references and plotted on the figures with a minimum of correction, so that additional errors would not be introduced. In the case of the $\Delta C_{L_{max.}}$ curve, the original data were plotted against flap deflection, and the trends as observed were used to correct to 45° deflection the data on wing-flap combinations having various flap chords. By this means a figure was prepared to correct $\Delta C_{L_{max.}}$ for chords other than the arbitrary 20 percent chord taken as standard. The data plotted on this figure at 20 percent chord have been based on ratios relative to the average curve of $\Delta C_{L_{max.}}$ against flap chord rather than on ratios relative to specific 20 percent chord cases. It is to be noted that the points on the charts, such as Figs. 2 and 3, where δ is the flap angle, have been corrected, so that they can not be compared directly with the original data from the references.

In several cases where either the deflection or chord correction was considerable, some variation from the average of the data is to be expected. Other corrections, such as that for the amount of span flapped, were somewhat arbitrary. This may account for the fact that points *a* are low relative to the majority. Points *b* are understood to be in error due to test inaccuracies. In drawing the flap-chord curves, more weight was given to the cases where more than two points were available to indicate the trend (points *c*, *d*, and *e*, for instance).

The centers of pressure at maximum lift coefficient were taken directly from the charts in the references, no corrections being made. The angles of attack at maximum lift coefficient were likewise taken directly from the charts, but in this case there was considerable variation with Reynolds Number. Curves of $\alpha_{C_{L_{max.}}}$ against Reynolds Number were plotted for a number of different wing-flap combinations, and from the general trend a common correction chart was derived. It was not necessary to correct $\alpha_{C_{L_{max.}}}$ for aspect ratio, inasmuch as all the data used were for an aspect ratio of 6, as was the case for the lift-drag ratio data.





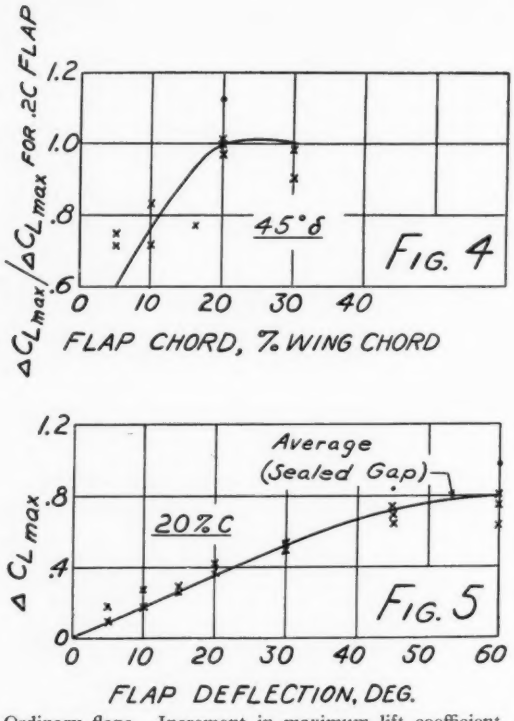
Split flaps. Increment in maximum lift coefficient, $\Delta C_{L_{max.}}$

In this analysis it was noticed that only a few of the reports had the results corrected for the tunnel boundary condition. The size of this correction as to angle of attack, drag, and the lift-drag ratio was investigated for a few random cases. It is believed that both the angle of attack and drag corrections are probably within the accuracy of reading the charts. The maximum lift-drag ratio is affected slightly, and there is some error introduced into the lift-drag ratio at 0.9 of the maximum lift coefficient. Therefore, where necessary, the data were corrected for these characteristics.

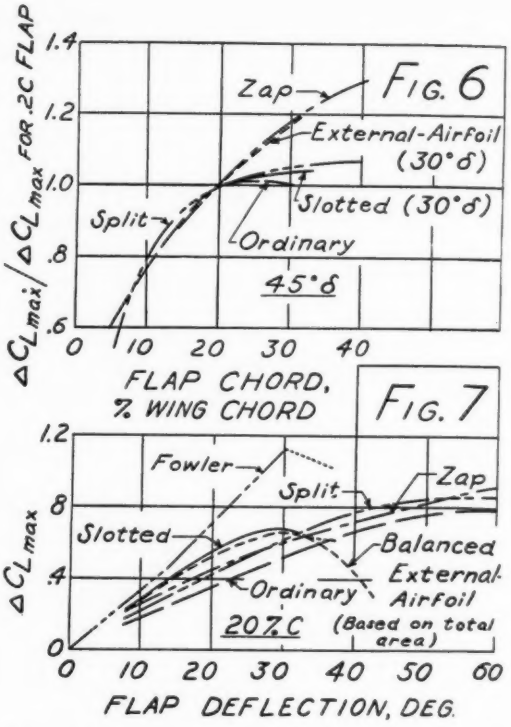
Scattering of $C_{L_{max.}}$ Points

Figs. 2 and 3, are based on a wing aspect ratio of 6, rectangular planform, constant wing thickness along the span, and 100 percent of the span flapped. No corrections have been made for wing thickness, camber, or camber position, all of which were found to influence $\Delta C_{L_{max.}}$.[2] This characteristic increases considerably with thickness, as is shown by a comparison of the solid and dotted lines which are for airfoils, respectively, 12 and 21 percent thick. The analysis indicates that $\Delta C_{L_{max.}}$ tends to decrease with combined increase in camber and movement of the position of maximum camber back along the wing chord.

Even with approximate allowances for the above variations, there were still discrepancies which could not be immediately accounted for. The scattering was of the order of 20 to 30 percent in $\Delta C_{L_{max.}}$ which corresponds roughly to 10 to 15 percent in $C_{L_{max.}}$



Ordinary flaps. Increment in maximum lift coefficient, $\Delta C_{L_{max.}}$



Comparison of flap types. Increment in maximum lift coefficient, $\Delta C_{L_{max.}}$, from average curves.

It seems possible that this situation may be due to four factors: some actual variation of $\Delta C_{L_{max.}}$ with Reynolds Number, turbulence, differences in testing technique, and dissimilar airfoil-surface conditions.

Analysis of data indicates that in the case of split flaps, there is actually some change of $\Delta C_{L_{max.}}$ with scale, which may be as great as 20 percent over a considerable Reynolds Number range.[2,3] This apparently accounts for a large part of the scattering, but it may be that the other three factors cannot be neglected.

It is felt in some circles that the criterion, "effective Reynolds Number," does not entirely account for the effect of tunnel turbulence on lift.[4] If this be true then possibly some change of $\Delta C_{L_{max.}}$ with turbulence may cause additional scattering of the data.

A recent note referring to flight testing for the maximum-lift coefficient[5] points out the "necessity of maintaining constant test conditions if consistent results are to be obtained." This is also true of wind-tunnel testing, not only for one type of flap, but for all types, if useful and valid comparisons are to be made. Errors in $C_{L_{max.}}$ due to testing technique have been practically eliminated in the major aeronautical laboratories, but this is not so true of the smaller laboratories.

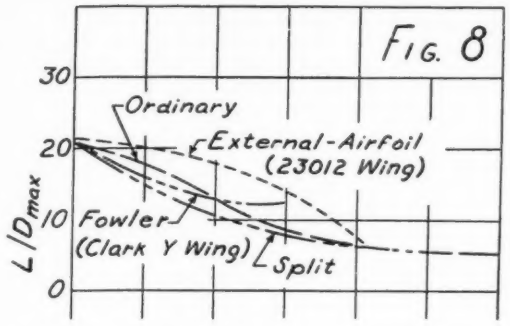
$C_{L_{max.}}$ depends on airfoil surface conditions, and it is well known that this effect becomes increasingly important at higher speeds.[6] It is possible that surface conditions also affect $\Delta C_{L_{max.}}$

It is apparent from Figs. 4 and 5 that for ordinary flaps there is considerably less scattering of the test points, and, when the variation of $\Delta C_{L_{max.}}$ with wing thickness is taken into account, the points appear to be more consistent than those for split flaps.

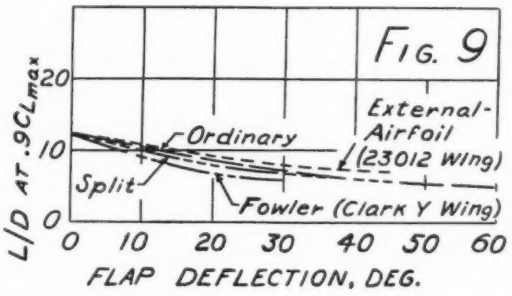
Importance of Accurate Comparative Flap Data

Figs. 6 and 7 consolidate all of the test data, relative to the lift-coefficient increments to be expected, into curves indicating the average $\Delta C_{L_{max.}}$ variations for these types of flaps. The small divergence among the curves shows the importance of accurate data in determining the superiority of one type over another. In this connection it should be emphasized that the information on the charts should not be considered as conclusive; the data on which they are based are not extensive enough to allow final deductions.

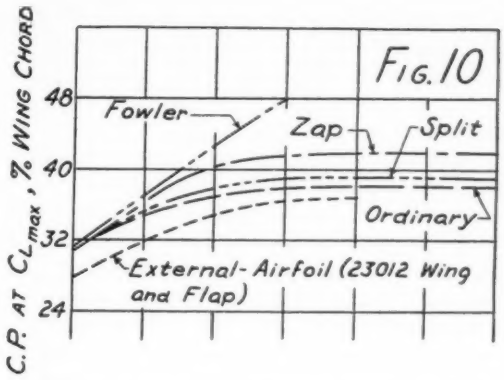
But $C_{L_{max.}}$ is not the only criterion of comparative flap performance. The maximum lift-drag ratio variation with deflection is interesting from the take-off viewpoint. Other factors which affect landing characteristics are: center of pressure travel at maximum lift, angle of attack at maximum-lift coefficient, and the lift-drag ratio at or near maximum lift. While one flap may give high lift, it may also have proportionately high drag and so be unsatisfactory for take-off. Another may have a large center of pressure travel, or, it may



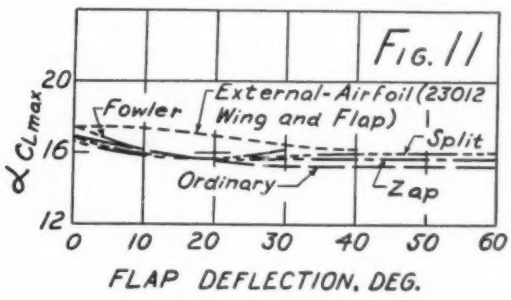
Comparison of flap types. Maximum lift-drag ratio, $(L/D)_{max.}$ Flap chord 20 percent of wing chord. Clark Y or N.A.C.A. 23012 wing except as noted.



Comparison of flap types. Lift-drag ratio at 0.9 of maximum lift coefficient, L/D at $.9C_{L_{max.}}$ Flap chord 20 percent of wing chord. Clark Y or N.A.C.A. 23012 wing except as noted. Effective Reynolds Number approximately 8.5×10^6.



Comparison of flap types. Center of pressure at maximum lift coefficient, C.P. at $C_{L_{max.}}$, percent of wing chord. Flap chord 20 percent wing chord. Clark Y wing except as noted.



Comparison of flap types. Angle of attack at maximum lift coefficient, $\alpha_{C_{L_{max.}}}$ Flap chord 20 percent wing chord. Clark Y wing except as noted. Effective Reynolds Number 3×10^6.

engender structural complications. Consequently, in order to choose a best all-around type, it is of considerable importance that these factors be accurately determined.

Figs. 8, 9, 10, and 11 illustrate how the above factors vary with flap deflection. However only four or five types of flaps are represented. Such data, as well as values of $C_{L_{max.}}$ and $\Delta C_{L_{max.}}$, are especially lacking for slotted flaps.

The limited amount of published information on this type indicates that $\Delta C_{L_{max.}}$ is quite consistent up to 30° deflection, but beyond this angle, slot shape is important, as shown by the fact that the trends above 30° are erratic. Because of the acuteness of the take-off problem, the simple slotted flap appears to offer a solution by providing high lift and low drag at low flap deflections. Further tests on this flap would be worthwhile.

Comparison of Flap Types

An analysis indicates that the Fowler is the most effective lift-producing device, but has the largest center of pressure travel. The curves show also that the Fowler has about an average $(L/D)_{max.}$ at low deflections, but is some what better than average above 20° deflection. The opening of the slot between the lower surface of the wing and the flap leading edge probably causes the drag to increase at a diminishing rate. There are indications that this flap has lower L/D's near maximum-lift coefficient than the ordinary or split flap.

As regards $\Delta C_{L_{max.}}$ the Zap and split flaps are the next most effective at the higher deflections. The Zap is seen to increase rapidly in effectiveness with increasing chord. However, this type has the disadvantage of a fairly high center of pressure travel.

The split flap is generally superior to the ordinary except that the latter has less center of pressure travel and has a higher maximum lift-drag ratio at all deflections up to 30°. The latter statement is also generally true of $(L/D)_{max.}$ at $0.9C_{L_{max.}}$

On the basis of existing information the slotted- and external-airfoil flaps give higher lift increments than all other types, except the Fowler, at flap deflections up to 30°. The balanced external airfoil provides higher maximum lift-drag ratios up to 30° than the split or ordinary. The external airfoil, like the Fowler and Zap flaps, becomes much more effective as regards $\Delta C_{L_{max.}}$ with increasing flap chord.

Additional Tests

It is apparent that the maximum-lift coefficient of a full-scale, high-aspect-ratio, swept-back wing, tapered in planform and thickness, perhaps embodying some twist or section change, and subjected or irregularities in profile shape, would be difficult to estimate from data on tests of model airfoils incorporating only a few of these design conditions. Exhaustive tests of flaps on wings embodying such a wide variety of features would not be warranted, but the effects of certain airfoil and flap design variables should be further investigated. A recent report[7] on split flaps on tapered airfoils is a valuable step in this direction.

The designer would probably rather make judicious use of such model test data, extrapolating it to full scale if necessary, than base his conclusions on estimates of wing-flap performance made from an integration of the performances of each section across the wing span. Of course, if this latter method works accurately enough for a majority of cases, it may be useful, if somewhat laborious, in complicated cases.

References

[1] Pearson, H. A., *A Method of Estimating the Aerodynamic Effects of Ordinary and Split Flaps on Airfoils Similar to the Clark Y*, N.A.C.A. Technical Note No. 571, page 13, 1936. See also N.A.C.A. Technical Report Nos. 554 and 558.

[2] Jacobs, E. N. and Sherman, A., *Airfoil Section Characteristics as Affected by Variations of the Reynolds Number*, N.A.C.A. Technical Report No. 586, 1937.

[3] Jones, R., Bell, A. N., and Smyth, E., *Tests on Aerofoil Flaps in the Compressed Air Tunnel*, British A.R.C., R. & M. No. 1636, 1935.

[4] Relf, E. F., *Recent Research on the Improvement of the Aerodynamic Characteristics of Aircraft*, Preprint of Royal Aeronautical Society paper, page 8, 1938.

[5] Soulé, H. A., and Hootman, J. A., *Flight Tests of an Airplane Showing Dependence of the Maximum Lift Coefficient on the Test Conditions*, N.A.C.A. Technical Note No. 622, page 8, 1937.

[6] Hooker, R. W., *The Aerodynamic Characteristics of Airfoils as Affected by Surface Roughness*, N.A.C.A. Technical Note No. 457, 1933.

[7] Wenzinger, C. J., *Wind Tunnel Investigation of Tapered Wings with Ordinary Ailerons and Partial Span Split Flaps*, N.A.C.A. Technical Report No. 611, 1937.

[8] Higgins, George J., *An Airfoil Fitted with a Slotted Flap*, Journal of the Aeronautical Sciences, Vol. 3, No. 12, page 431, October, 1936.

Letter to the Editor

Dear Sir:

In the February, 1938 issue of the Journal, Albert Sherman presented a paper entitled "An Integrator for Evaluating the Downwash from a Span-Loading Curve." The present letter concerns the determination of the downwash at the tailplane.

The mechanical integrator developed by Sherman can be used to determine the downwash of a *spanwise* section. But for the solution of other questions of practical importance, especially of the problem of longitudinal stability of the airplane, it is desirable to know the downwash at a point *behind the wing, e.g.*, near the tailplane. Sherman's integrator may be adapted to the solution of this problem.

We assume, as Sherman did, that the span-load distribution of the wing is known, *i.e.*, $\gamma = c_L \cdot c/2b$ is given as a function of $\eta = 2y/b$. Following Prandtl's lifting-line theory (assuming that the vortex sheet behind the wing has not yet rolled up) the angle of downwash at a point, $\xi_1 = 2x_1/b$; $\eta_1 = 2y_1/b$; $z = 0$, behind the wing may be written

$$\frac{w}{v} = \frac{1}{2\pi}\int_{-1}^{+1}\frac{d\gamma}{d\eta}\left(1 + \frac{\sqrt{\xi_1^2 + (\eta - \eta_1)^2}}{\xi_1}\right)\frac{d\eta}{\eta - \eta_1} \qquad (1)$$

Introducing an angle α defined by

$$\tan\alpha = (\eta - \eta_1)/\xi_1$$

(see Fig. 1) Eq. (1) can be simplified to read

$$\frac{w}{v} = \frac{1}{2\pi\xi_1}\int_{-1}^{+1}\left(\frac{1}{\tan\alpha} + \frac{1}{\sin\alpha}\right)d\gamma = \frac{1}{2\pi\xi_1}\int_{-1}^{+1}\frac{d\gamma}{\tan(\alpha/2)}$$

and with $\tan(\alpha/2) = a$ we obtain

$$w/v = (1/2\pi\xi_1)\int_{-1}^{+1} d\gamma/a \qquad (2)$$

Now we have expressed the relation for the downwash behind the wing in a form corresponding exactly to that for which Sherman's integrator has been designed. We have only to provide that the carriage has not the η-position of the tracing pointer A, but follows the η-position of B, whose distance from the point η_1 is a. The desired movement of point B may be provided for quite simply, perhaps by beams as indicated in the figure, or by cog-wheels.

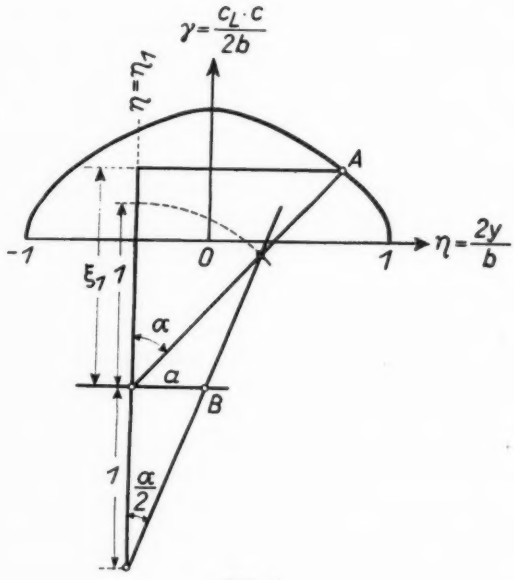


FIG. 1.

The uncertain properties of the integrator in the region of the singular point can be avoided by arranging the integrator before measuring in such a manner that the angle θ (Sherman) is zero at the point η_1.

DIETRICH KÜCHEMANN
Göttingen, Germany

Special Problems Connected with the Take-Off and Landing of Aircraft

J. J. GREEN, *National Research Laboratories, Canada*

Presented at the Air Transport Session, Sixth Annual Meeting, I. Ae. S.
January 27, 1938

ABSTRACT

A theoretical analysis has been made of the effect of gradient, wind, and combinations thereof, on the take-off and landing of aeroplanes. Formulas and charts are given which permit the determination of the length of the ground run for any given conditions providing that the performance on a level surface in still air is known.

The effect of wind and current on the take-off of seaplanes has also been investigated. Formulas and charts have been derived for the determination of take-off times and distance under any given conditions from a knowledge of the take-off speed, time, and distance in still air and still water. This analysis indicates that in the take-off of seaplanes the wind is in general of more importance than the current, and, in consequence, take-off should always be carried out upwind.

A FEW aerodromes are in existence on which there is a gradient in the direction of take-off and landing. As this feature may in general be a disadvantage, an investigation has been made on the effect of varying wind and gradient on the take-off run and landing run of aeroplanes. This investigation is carried out in part I of this paper. In part II a somewhat similar problem has been analyzed, *viz.*, the effect of wind and current on the take-off of seaplanes.

I

THE EFFECT OF WIND AND GRADIENT ON THE TAKE-OFF AND LANDING OF AEROPLANES

In analyzing the effect of wind and gradient on the take-off and landing runs of aeroplanes, three cases have been considered: (1) the effect of gradient in the absence of wind; (2) the effect of wind in the absence of a gradient; (3) the combined effect of wind and gradient. The analysis is based on uniform gradients, and, since the results are referred to the performance on a level aerodrome, the type of surface on the gradient is assumed to be the same as on the level surface for which take-off and landing characteristics of any particular aeroplane are known. The wind is assumed to be blowing either directly up or down the gradient. Theoretical formulas have been developed giving the effect of gradient, wind, and combined wind and gradient on the take-off time and distance, and the landing run.

The effect of gradient in the absence of wind is capable of almost exact solution. The theoretical treatment of the effect of wind on take-off leads to a formula that differs slightly, in its predictions, from the results of measured take-offs. By slight modification the formula has been made to agree closely with the results of tests. Charts have been prepared showing the effect of wind and gradient on the take-off and landing runs of aeroplanes of which the take-off and landing speeds in still air are included in the range 35 to 75 m.p.h.

SYMBOLS USED

m = Mass of aircraft.
g = Acceleration due to gravity, taken as 32.2 ft. per sec.^{2}
θ = Angle of gradient (radians).
x = Gradient defined as rise per 100 ft./100; for small slopes $\theta = x$.
V_T = Take-off speed (still air), in feet per second when used in the formulas but given in miles per hour on the charts.
V_L = Landing speed (still air), in feet per second in the formulas but given in miles per hour on the charts.
t_1 = Take-off time or duration of landing run in seconds on a level surface in still air.
t_2 = Take-off time or duration of landing run in seconds resulting from the effect of grade or wind or both.
D_1 = Take-off run or landing run in feet on a level surface in still air.
D_2 = Take-off run or landing run in feet resulting from the effect of grade or wind or both.
f = Mean acceleration during take-off or mean deceleration during landing in feet per sec.^{2}
v_w = Wind speed, in feet per second when used in the formulas.

EFFECT OF GRADIENT IN THE ABSENCE OF A WIND

Take-Off Upgrade

The retarding force due to the gradient will be $mg \sin \theta$, hence the deceleration will be $g \sin \theta$, and since θ will in general be small this can be written $g\theta$ or xg. If V_T and t_1 are the take-off speed and time on the level, then after a time t_1 on the gradient the velocity will be $V_T - xgt_1$. If t_2 is the take-off time up the gradient, then on the level after time t_2 the velocity would have been $V_T t_2/t_1$, but owing to the gradient this is reduced to

$$(V_T t_2/t_1) - xgt_2 = V_T$$

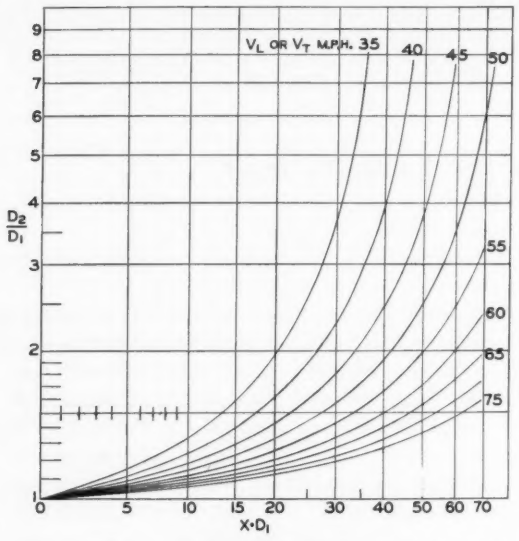


FIG. 1. Effect of gradient in the absence of wind on the length of the take-off run up the gradient or the landing run down the gradient.

from which one obtains

$$t_2/t_1 = 1/[1 - (xgt_1/V_T)] \tag{1}$$

This equation gives the take-off time up the gradient in terms of the take-off speed, the take-off time on the level, and x, the gradient. Eq. (1) gives immediately the conditions under which take-off is impossible, for when $1 - (xgt_1/V_T) = 0$, t_2 becomes infinite. Hence take-off becomes impossible when

$$xgt_1/V_T = 1 \text{ or } x = V_T/gt_1$$

Since x is now likely to be large this should be written

$$\sin\theta = V_T/gt_1 \tag{2}$$

From which the value of θ for which take-off is impossible is given in terms of g and the take-off speed in feet per second and take-off time on the level.

For take-off on the level

$$D_1 = V_T^2/2f \text{ or } f = V_T^2/2D_1$$

Similarly up the gradient

$$D_2 = V_T^2/2(f - xg) = V_T^2/2[(V_T^2/2D_1) - xg]$$

Hence

$$D_2/D_1 = 1/[1 - (2xgD_1/V_T^2)] \tag{3}$$

gives the take-off distance up the gradient in terms of take-off characteristics on the level.

Eq. (3) could be derived directly from Eq. (1) by substituting

$$D_1 = V_T t_1/2 \text{ and } D_2 = V_T t_2/2$$

Fig. 1 contains curves from which the ratio D_2/D_1 can be read off for the appropriate value of xD_1 and the take-off speed V_T of the aeroplane under consideration.

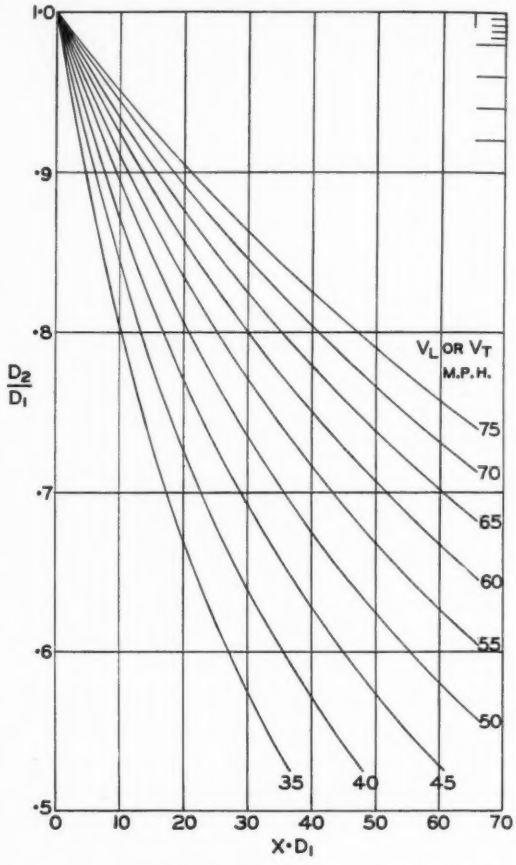


FIG. 2. Effect of gradient in the absence of wind on the length of the take-off run down the gradient or the landing run up the gradient.

Take-Off Downgrade

By similar treatment the equations for take-off time and distance down the gradient are found to be:

$$t_2/t_1 = 1/[1 + (xgt_1/V_T)] \tag{4}$$

$$D_2/D_1 = 1/[1 + (2xgD_1/V_T^2)] \tag{5}$$

Fig. 2 contains curves from which the ratio D_2/D_1 can be read off for the appropriate value of xD_1 and the take-off speed of the aeroplane under consideration.

Landing Run Upgrade

On the level surface with no wind, the time t_1 for the landing run is given by the equation $t_1 = V_L/f$, where V_L = landing speed in feet per second, and f = mean deceleration in feet per sec.[2]

The length of the landing run is given by

$$D_1 = V_L t_1 - f t_1^2/2$$

and substituting for t_1, one obtains $D_1 = V_L^2/2f$ from which $f = V_L^2/2D_1$. The equations for time and distance of the upgrade landing run will be

$$t_2 = \frac{V_L}{f + xg} \text{ and } D_2 = \frac{V_L^2}{2(f + xg)}$$

and by substituting for f

$$D_2 = V_L^2/2[(V_L^2/2D_1) + xg]$$

$$\text{or } D_2/D_1 = 1/[1 + (2xgD_1/V_L^2)] \quad (6)$$

which is an equation identical with that for the take-off run downgrade except for the substitution of V_L for V_T.

From the curves of Fig. 2 the ratio of the upgrade landing run to the level surface landing run can be read off at the appropriate value of xD_1 and the landing speed V_L of the aeroplane under consideration.

Landing Run Downgrade

The equations for the time and distance of the landing run downgrade follow from the foregoing treatment,

$$t_2 = \frac{V_L}{f - xg} \quad \text{and} \quad \frac{D_2}{D_1} = \frac{1}{1 - \frac{2xgD_1}{V_L^2}} \quad (7)$$

which is an equation similar to that for the take-off run upgrade, except that V_T is replaced by V_L.

The curves of Fig. 1 enable the landing run downgrade to be evaluated at the appropriate values of x, D_1, and V_L.

Effect of Wind in the Absence of a Gradient

Take-Off Upwind

With the notation used before and assuming that the mean acceleration f remains the same in a wind, $V_T - v_w = ft_2$ where v_w is the wind velocity and t_2 the new take-off time. By substituting for f

$$V_T - v_w = V_T t_2/t_1$$

therefore

$$t_2/t_1 = [1 - (v_w/V_T)] \quad (8)$$

If D_1 and D_2 are the corresponding take-off runs then

$$D_2/D_1 = (t_2/t_1)^2 = [1 - (v_w/V_T)]^2 \quad (9)$$

Diehl's curve[1] of measured take-off runs plotted for various wind speeds has been replotted in Fig. 3 together with Eq. 9. It is obvious that Eq. 9 leads to smaller take-off runs than are achieved in actual practice. It follows, therefore, that the assumption of the same mean acceleration against a wind as in still air does not agree exactly with actual behavior during take-off, and that the mean acceleration against a wind must be less than that in still air. The equation

$$D_2/D_1 = [1 - (v_w/V_T)]^{1.5} \quad (10)$$

agrees very closely with the measured effect of wind on take-off run (Fig. 3).

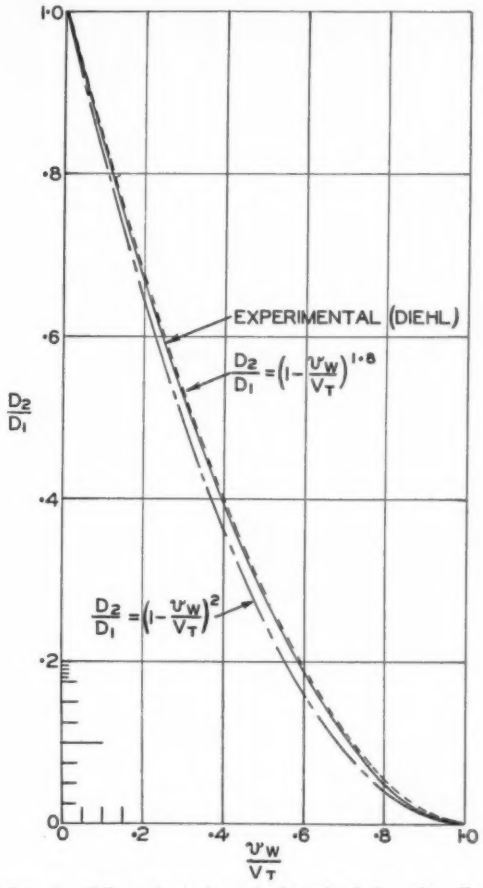


Fig. 3. Effect of wind on the length of the take-off run from a level surface.

Take-Off Downwind

For this condition, $V_T + v_w = ft_2$ (on the assumption that the mean acceleration downwind is the same as in still air), and therefore,

$$t_2/t_1 = [1 + (v_w/V_T)] \quad (11)$$

The distance is given by

$$D_2/D_1 = [1 + (v_w/V_T)]^2 \quad (12)$$

It is apparent from the upwind treatment that in actual practice the mean downwind acceleration is likely to be greater than the mean acceleration in still air, and that the take-off distances will probably be more accurately given by

$$D_2/D_1 = [1 + (v_w/V_T)]^{1.5} \quad (13)$$

which is obtained by giving v_w a negative sign in the formula for upwind take-off.

Landing Run Upwind

For the no-wind case $V_L = ft_1$ where f is the mean deceleration, and for the upwind case $V_L - v_w = ft_2$ the same deceleration being assumed.

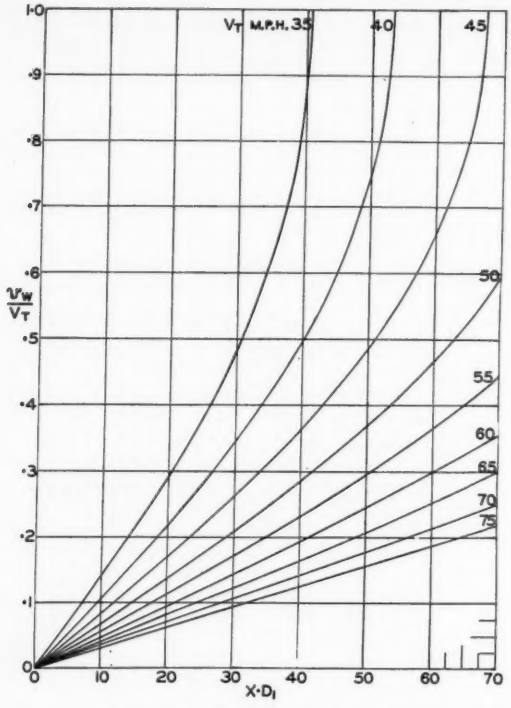


FIG. 4. Curves for the determination of the critical wind velocity for take-off on a gradient.

Hence

$$t_2/t_1 = [1 - (v_w/V_L)] \tag{14}$$

If D_1 and D_2 are the corresponding landing runs then,

$$D_1 = V_L^2/2f \text{ and } D_2 = (V_L - v_w)^2/2f$$

Therefore

$$D_2/D_1 = [1 - (v_w/V_L)]^2 \tag{15}$$

Landing Run Downwind

By similar treatment the downwind times and distances will be given by

$$t_2/t_1 = [1 + (v_w/V_L)] \tag{16}$$

and

$$D_2/D_1 = [1 + (v_w/V_L)]^2 \tag{17}$$

COMBINED EFFECT OF GRADIENT AND WIND

When the wind is blowing up the gradient, take-off will be made down the gradient since both the slope and the wind will be effective in reducing the take-off time and run. Similarly when the wind is blowing down the gradient, landing will be made up the gradient since both the slope and the wind will be effective in reducing the landing run. Since these cases present no difficulty, charts have not been prepared for them.

Two cases are now considered: (1) take-off with the wind blowing down the gradient; (2) landing with the wind blowing up the gradient. In both, the effects of wind and gradient are acting against each other. It is obvious that for winds whose velocities are below a certain critical velocity the effect of the gradient will predominate, and for winds stronger than the "critical wind" the effect of the gradient will be less than the effect of the wind. For winds whose velocities are below the critical wind velocity, take-off must be carried out down the slope (downwind) and landings made up the slope (downwind), but, for winds whose velocities are above the critical velocity, take-offs and landings must be made into wind.

Take-Off with the Wind Blowing Down the Gradient

From the preceding treatment it follows that for the upgrade take-off the length of run will be given by

$$\frac{D_2}{D_1} = \left\{\frac{1}{1 - \frac{2xgD_1}{V_T^2}}\right\}\left\{1 - \frac{v_w}{V_T}\right\}^{1.8} \tag{18}$$

where the first term gives the unfavorable effect of slope and the second term gives the favorable effect of wind.

The downgrade take-off run will be given by

$$\frac{D_2}{D_1} = \left\{\frac{1}{1 + \frac{2xgD_1}{V_T^2}}\right\}\left\{1 + \frac{v_w}{V_T}\right\}^{1.8} \tag{19}$$

The ratio

$$\frac{\text{upgrade run}}{\text{downgrade run}} = \left\{\frac{V_T^2 + 2xgD_1}{V_T^2 - 2xgD_1}\right\}\left\{\frac{V_T - v_w}{V_T + v_w}\right\}^{1.8}$$

and for the critical wind velocity this ratio must be unity, which leads to

$$xD_1 = \frac{V_T^2}{2g}\left\{\frac{\left(1 + \frac{v_w}{V_T}\right)^{1.8} - \left(1 - \frac{v_w}{V_T}\right)^{1.8}}{\left(1 + \frac{v_w}{V_T}\right)^{1.8} + \left(1 - \frac{v_w}{V_T}\right)^{1.8}}\right\} \tag{20}$$

which for any particular aeroplane gives the critical take-off wind velocity for a given gradient.

Eq. (20) has been used to prepare the curves of Fig. 4 for the determination of the critical take-off wind velocity for any given gradient. From the appropriate values of xD_1 and V_T the take-off speed, the value of v_w/V_T can be read off and hence the value of v_w, the critical wind velocity for take-off.

Landing with the Wind Blowing Up the Gradient

From the foregoing treatment it follows that the upgrade landing run will be given by

$$\frac{D_2}{D_1} = \left\{\frac{1}{1 + \frac{2xgD_1}{V_L^2}}\right\}\left\{1 + \frac{v_w}{V_L}\right\}^2 \tag{21}$$

and the downgrade landing run will be given by

$$\frac{D_2}{D_1} = \left\{\frac{1}{1 - \frac{2xgD_1}{V_L^2}}\right\}\left\{1 - \frac{v_w}{V_L}\right\}^2 \qquad (22)$$

by equating these for the critical wind velocity

$$xD_1 = \frac{V_L^2}{2g}\left\{\frac{\left(1 + \frac{v_w}{V_L}\right)^2 - \left(1 - \frac{v_w}{V_L}\right)^2}{\left(1 + \frac{v_w}{V_L}\right)^2 + \left(1 - \frac{v_w}{V_L}\right)^2}\right\}$$

$$= (V_L^2/2g)\{2v_wV_L/(V_L^2 + v_w^2)\}$$
$$= (V_L^2/g)\{(v_w/V_L)/[1 + (v_w/V_L)^2]\} \qquad (23)$$

The curves of Fig. 5 have been prepared from Eq. (23) for the determination of the critical landing wind velocity for any given gradient, and are used in the same manner as the curves of Fig. 4.

Eqs. (21) and (22) must be used for the determination of the length of run under any given conditions of wind and grade. It must be remembered that all speeds used in the formulas must be in ft. per sec.

Although curves are not given for the length of run in the two favorable cases where gradient and wind effects are working together, the formulas for the length of run in these cases are as follows:

Wind Blowing Up the Gradient for Take-Off

The length of run, if the take-off is down the gradient, will be given by

$$D_2/D_1 = \{1/[1 + (2xgD_1/V_T^2)]\}\{1 - (v_w/V_T)\}^{1.8} \qquad (24)$$

Wind Blowing Down the Gradient for Landing

The length of run, if the landing is up the gradient, will be given by

$$D_2/D_1 = \{1/[1 + (2xgD_1/V_L^2)]\}\{1 - (v_w/V_L)\}^2 \qquad (25)$$

II

The Effect of Wind and Current on the Take-Off of Seaplanes

The effect of wind and current on the take-off of seaplanes has been analyzed by using the simplifying assumption that the mean acceleration during take-off is independent of wind or current. Approximate expressions have been derived for the take-off time and distance in a wind with no current, in a current with no wind, and for the case where both wind and current are present. Curves have been prepared from which time and distance can be rapidly derived for any particular case. The following conclusions have been drawn.

(1) The effect of wind alone on take-off distance is more marked than its effect on take-off time.

(2) The effect of current alone on take-off distance is less marked than its effect on take-off time.

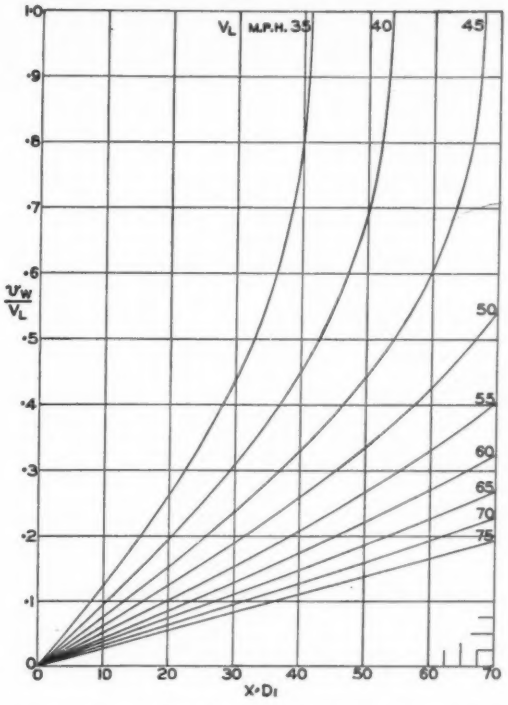


Fig. 5. Curves for the determination of the critical wind velocity for landing on a gradient.

(3) The effect of current on take-off time is closely analogous to the effect of wind on take-off time but is of opposite sign. In taking-off against a current the overall take-off distance (referred to shore) is exactly the same as the distance for take-off in still water. In taking-off with a current there is a very small saving in take-off distance over that in still water.

In general, irrespective of the direction of the current, there will be a saving in take-off distance if the take-off is made into wind. The time of take-off will also be reduced except for that case in which the velocity of the current exceeds that of the wind, and both are in the same direction.

Symbols Used

V_T = Take-off speed of seaplane (still air).
t_1 = Take-off time in seconds in the absence of wind and current.
t_2 = Take-off time in seconds resulting from the effect of wind or current or both.
D_1 = Take-off run in the absence of wind and current.
D_2 = Take-off run resulting from the effect of wind or current or both.
f = Mean acceleration during take-off.
v_w = Wind speed.
v_c = Speed of current.

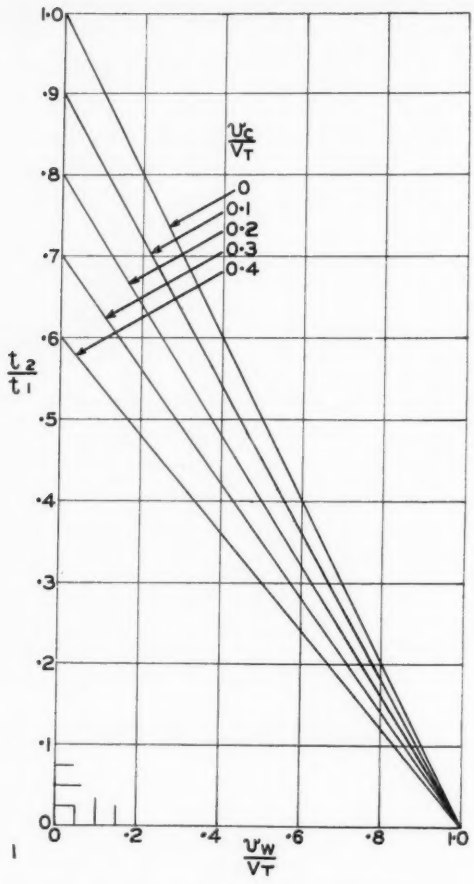


FIG. 6. Take-off time upwind with the current.

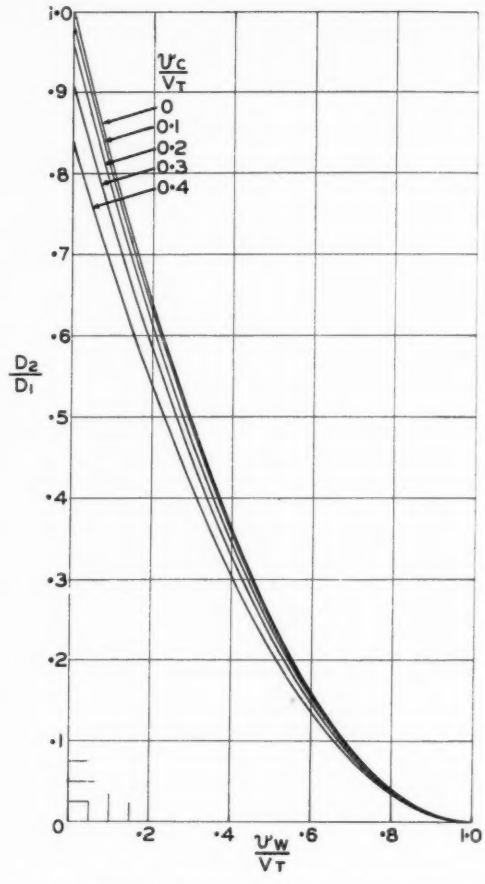


FIG. 7. Take-off distance upwind with the current.

EFFECT OF WIND IN THE ABSENCE OF CURRENT

The effect of wind alone on take-off time and distance has already been analyzed in part I for landplanes. For a seaplane, identical expressions are obtained.

Upwind

Take-off time

$$t_2/t_1 = [1 - (v_w/V_T)] \tag{26}$$

Take-off distance

$$D_2/D_1 = [1 - (v_w/V_T)]^2 \tag{27}$$

In the case of landplanes it was noted that Eq. (27) did not agree with the results of actual take-off tests.

In the case of seaplanes it has been found[2] that the actual take-off times in a wind are given very closely by Eq. (26), and hence, Eq. (27) for the take-off distance, derived from Eq. (26), is considered to hold with reasonable accuracy.

Downwind

The equations for downwind take-off time and distance will be,

$$t_2/t_1 = [1 + v_w/V_T] \tag{28}$$

and

$$D_2/D_1 = [1 + (v_w/V_T)]^2 \tag{29}$$

These four equations have been plotted on the charts as the special case

$$v_c/V_T = 0$$

EFFECT OF CURRENT IN THE ABSENCE OF WIND

Take-Off with the Current

For the case of zero current

$$V_T = ft_1$$

and taking-off with the current

$$V_T = v_c + ft_2$$

(the same mean acceleration as in still water is assumed).

By substituting for f and rearranging,

$$t_2/t_1 = [1 - (v_c/V_T)] \tag{30}$$

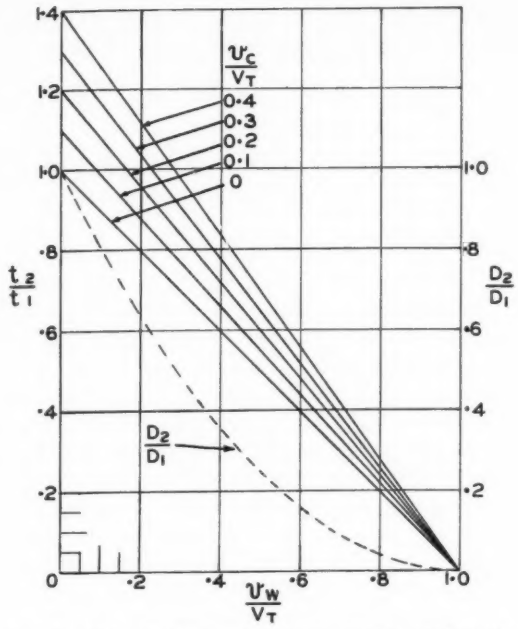


FIG. 8. Take-off time and distance upwind against the current.

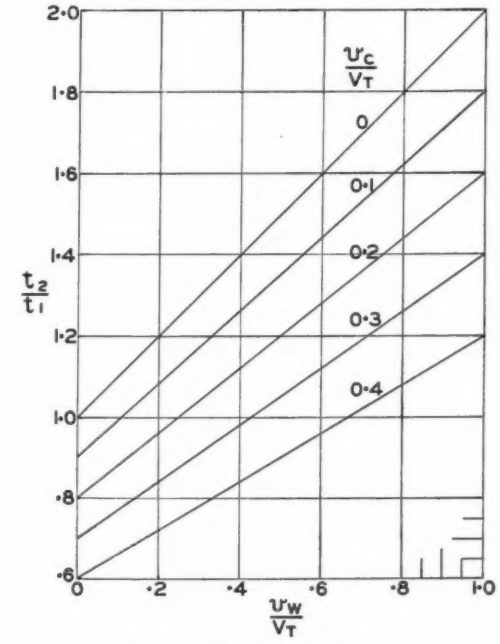


FIG. 9. Take-off time downwind with the current.

Again, for zero current $V_T^2 = 0 + 2fD_1$ and with the current $V_T^2 = v_c^2 + 2fD_2 = v_c^2 + V_T^2 D_2/D_1$

Therefore

$$D_2/D_1 = 1 - (v_c/V_T)^2 \qquad (31)$$

The values of t_2/t_1 and D_2/D_1 can be read from Figs. 6 and 7 for any particular value of the ratio v_c/V_T.

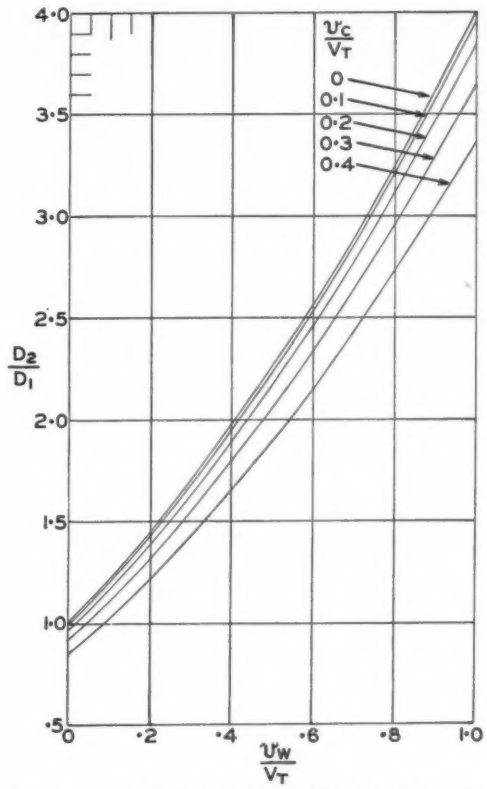


FIG. 10. Take-off distance downwind with the current.

The take-off distance given by Eq. (31) refers, of course, to distance relative to the shore. The take-off distance measured along the surface of the water is given by

$$(V_T - v_c)^2 = 0 + 2fD_2 = V_T^2 D_2/D_1$$

Therefore

$$D_2/D_1 = [1 - (v_c/V_T)]^2 \qquad (31a)$$

It is considered that distance measured along the water surface is less important than distance referred to shore. Eq. (31) and Fig. 7 show that the effect of current on take-off distance referred to the shore is very small indeed.

Take-off against the Current

In still water $V_T = ft_1$, and against a current $V_T + v_c = ft_2 = V_T t_2/t_1$.

Therefore

$$t_2/t_1 = [1 + (v_c/V_T)] \qquad (32)$$

Again, the overall distance required to take off against the current reckoned from the point at which the backward drift with the current ceases to the take-off point is given by

$$V_T^2 = 0 + 2fD_2$$

but in still water,

$$V_T^2 = 0 + 2fD_1$$

Therefore

$$D_2 = D_1 \tag{33}$$

The value of t_2/t_1 given by Eq. (32) can be read from Fig. 8 for the case $v_w/V_T = 0$.

The take-off distance given by Eq. (33) is again referred to shore, and is the same as the take-off run in still water and still air.

The take-off distance measured along the surface of the water will be given by

$$(V_T + v_c)^2 = 0 + 2fD_2$$
$$= V_T^2 D_2/D_1$$

Therefore

$$D_2/D_1 = [1 + (v_c/V_T)]^2 \tag{33a}$$

Again, this distance is unimportant unless the question arises of clearing obstacles on the surface that are moving with the current.

Combined Effect of Wind and Current

It is obvious from the foregoing treatment that the equations for take-off times and distances will be as follows:

Wind and Current in Opposite Directions

Case A. Take-off with the current (upwind)

$$t_2/t_1 = [1 - (v_c/V_T)][1 - (v_w/V_T)]$$
$$D_2/D_1 = [1 - (v_c^2/V_T^2)][1 - (v_w/V_T)]^2$$

Case B. Take-off against the current (downwind)

$$t_2/t_1 = [1 + (v_c/V_T)][1 + (v_w/V_T)]$$
$$D_2/D_1 = [1 + (v_w/V_T)]^2$$

Wind and Current in the Same Direction

Case C. Take-off with the current (downwind)

$$t_2/t_1 = [1 - (v_c/V_T)][1 + (v_w/V_T)]$$
$$D_2/D_1 = [1 - (v_c^2/V_T^2)][1 + (v_w/V_T)]^2$$

Case D. Take-off against the current (upwind)

$$t_2/t_1 = [1 + (v_c/V_T)][1 - (v_w/V_T)]$$
$$D_2/D_1 = [1 - (v_w/V_T)]^2$$

Obviously Case A (*i.e.*, upwind) is the correct way to take off since there is a saving both in time and distance over the still water, no-wind take-off. Case B causes a loss in both time and distance.

As regards the latter condition, even for the very lightest winds there will be a saving in distance by taking-off into wind (Case D), since even for large values of v_c, the value of v_c^2/V_T^2 is small, and the effect of the current in reducing take-off run in Case C is consequently almost negligible in comparison with the unfavorable effect of even moderate winds. The time of take-off will also be reduced by taking off upwind, providing that the velocity of the wind is greater than that of the current. If this is not the case the take-off time will be increased.

Cases A, C, and D are given in the curves of Figs. 6, 7; 9, 10; and 8.

Acknowledgment

The Author is indebted to J. R. K. Main of the Department of Transport who suggested the investigation.

References

[1] Diehl, W. S., *Engineering Aerodynamics*, page 440, The Ronald Press Company, New York. 1936.

[2] Jones, E. T., *Effect of Wind on the Take-Off of Seaplanes*, British A.R.C., R. & M. No. 1593, 1934.

Letter to the Editor

May 12, 1938

Dear Sir:

Supplementing the articles dealing with specific problems on the stratosphere the following general information may be in place and of interest to the readers of the Journal.

The University of Minnesota, Department of Aeronautical Engineering, in the spring of 1936 established a special professorship devoted to the study of problems pertaining to the stratosphere. This is the first university in the United States to establish such a professorship for undergraduate and graduate courses.

Dr. Jean F. Piccard, noted stratospherist, was appointed to this professorship and under his leadership regular lectures and research work by graduate and undergraduate students of the Department of Aeronautical Engineering was started at that time.

As a result of these two years of work many research problems and practical applications have been undertaken at the University of Minnesota. With the cooperation of Dr. Piccard the Divisions of Aircraft Structures, Internal Combustion Engines, Meteorology, and Radio have undertaken to solve many problems pertaining to stratosphere flight. Most of the work is done as research problems for the industry or as individual research of professors or graduate students. To name only a few I might mention: (1) automatic inside cabin control valve, (2) non-frost wind shield, (3) air conditioning system and apparatus, (4) leak proof cabin construction, (5) door seal, (6) radio meteorographs, and (7) development of composite aerostat.

Our extensive aeronautical laboratory facilities have been adjusted to the requirements necessary for experiments pertaining to stratosphere flying. Graduate work for students has been arranged so that they can specialize in stratosphere problems.

John D. Akerman
University of Minnesota

Principle and Tests of the Mirror Type Pitot

ALEXANDER KLEMIN, *New York University*

Presented at the Instruments Session, Sixth Annual Meeting, I. Ae. S.
January 24, 1938

A CONSIDERABLE amount of experimental work, both in the wind tunnel and in full flight, has been carried out on the best location in which to place a pitot tube so that its readings may be correct at varying angles of attack in spite of wing interference. The literature of the subject is extensive. No entirely satisfactory position has been found even for the unflapped wing, although experimentation seems to indicate the following rules for monoplanes; (1) neither too near the tip, nor too near the fuselage, but about 40 percent of the semi-span from the outer tip, (2) either 40 percent of the chord ahead of the leading edge, or (3) in a region about 25 percent of the chord to the rear of the trailing edge and 35 percent above.

In the case of biplanes, a normal and generally satisfactory location is on one of the interplane struts, at 50 to 60 percent of the gap above the lower wing.

For wings with flaps no position has as yet been found which may be considered satisfactory because of the wide differences in the magnitude and direction of the airflow produced by varying flap depression. On the basis of the single experiment here reported and on the basis of theoretical reasoning, it can be conjectured that if a pitot is to be placed inboard of the outer tip of the flap, then it should be carried out well ahead of the leading edge, half a chord length or more, and if possible, be hinged so as to align itself with the wind. Alternatively, for a wing in which flaps are applied over a portion of the span, the pitot might well be placed outboard of the flap, say halfway between the tip of the wing and the outer tip of the flap and aft of the trailing edge and above the wing.

Even if it were granted that a satisfactory position always exists theoretically no matter what the aircraft employed may be, difficulties would remain. First, finding this location might be a lengthy and tedious process; second, a location suitable on aerodynamic grounds may lead to difficulties of installation, such as very long leads, or leads requiring many bends with consequent lag in indication, and third, the final adjustment of the pitot position would be difficult.

It occurred to the author that a pitot which would indicate correctly through a wide range of speeds, with approximate independence of its location, and independently of flap depression, might perhaps be achieved by placing the pitot in proximity to a small auxiliary airfoil which would counteract the aerodynamic effects of the main wing. To this device the name Mirror Type Pitot was applied, although it is not entirely logical.

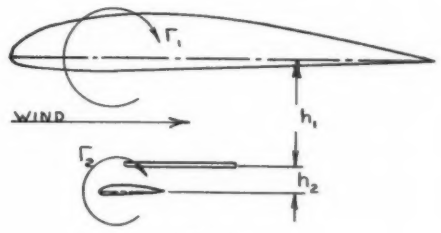


FIG. 1.

ELEMENTARY THEORY OF THE MIRROR TYPE PITOT

The elementary theory of the Mirror Type Pitot is illustrated by Fig. 1. Imagine that a pitot is placed at some distance below the main wing carrying a circulation of strength Γ_1 and that a small auxiliary wing carrying a circulation Γ_2 is placed at a short distance below the pitot. The circulation of the upper wing retards the velocity by the amount $\Gamma_1/2\pi h_1$, while the auxiliary wing increases the velocity by the amount $\Gamma_2/2\pi h_2$. If $\Gamma_1/h_1 = \Gamma_2/h_2$ or $\Gamma_1 h_2 = \Gamma_2 h_1$, the aerodynamic effects annul each other.

In reality the interferences are much more complex, and the form of the wings, their aspect ratios, taper, location of the pitot relative to the chords of the two wings, variation in curvature of the streamlines due to the circulatory flow all enter into the problem. A purely theoretical approach is out of the question, and experimentation is necessary.

TESTS WITH A SMALL PITOT AND TWO RECTANGULAR WINGS (NO FLAP)

A small pitot $^1/_{16}$ in. in diameter with a head of the Prandtl or Pioneer type was employed. An R.A.F. 48 wing section (48 × 8 in.) was used as the main wing and a smaller R.A.F. 48 (12 × 2 in.) was used as the "Mirror" wing. The axis of the pitot was parallel to the chord of the main wing, 2 in. below it, and with its nose at $^1/_3$ of the chord from the leading edge. The mirror wing was mounted successively at $^1/_4$ in.,

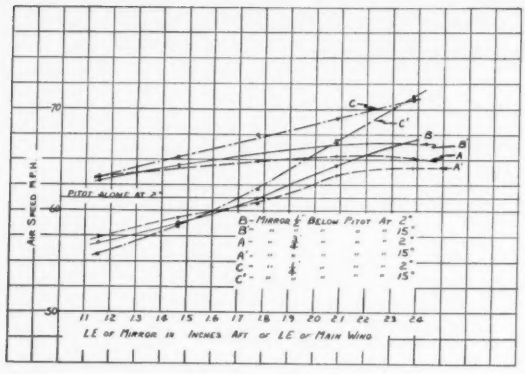

AIR SPEED M.P.H.
70
60
50
PITOT ALONE AT 2°
B-MIRROR ¾ BELOW PITOT AT 2°
B' " " " " 15°
A- " ¾ " " 2°
A' " " " " 15°
C- " ¾ " " 2°
C' " " " " 15°
11 12 13 14 15 16 17 18 19 20 21 22 23 24
L.E. OF MIRROR IN INCHES AFT OF L.E. OF MAIN WING

FIG. 2.

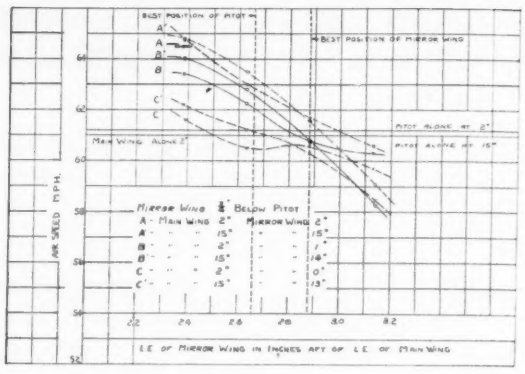

BEST POSITION OF PITOT
BEST POSITION OF MIRROR WING
PITOT ALONE AT 2°
PITOT ALONE AT 15°
MAIN WING ALONE
AIR SPEED M.P.H.
MIRROR WING ¾ BELOW PITOT
A - MAIN WING 2° MIRROR WING 2°
A' " " 15° " " 15°
B " " 2° " " 1"
B' " " 15° " " 14"
C " " 2° " " 0"
C' " " 15° " " 13"
22 24 26 28 30 32
L.E. OF MIRROR WING IN INCHES AFT OF L.E. OF MAIN WING

FIG. 3.

½ in., and ¾ in. below the pitot, placed with its leading edge 1 in. from the leading edge of the main wing and moved progressively backward, its incidence also being varied. The experiments were repeated at 2° and 15° angles of attack of the main wing. The wind-tunnel speed was kept constant at about 60 m.p.h.

Figs. 2 and 3 indicate the results obtained for various horizontal positions and settings of the mirror wing. The vertical line indicates the position of the mirror wing when its leading edge was on the same vertical line as the nose of the pitot. Fig. 4 indicates the arrangement which may be taken as the "best" combination.

From a study of these curves the following conclusions may be drawn:

(1) At the low angle of attack, 2° incidence, the main wing lowers the reading of the pitot only moderately. At 15° incidence, the drop in pitot tube indication is very marked, namely from 61 m.p.h. (which may be taken as the true air speed) to 52 m.p.h.

(2) As the mirror wing is placed closer to the pitot in a vertical direction its corrective action increases. It will be noted that in the "best" position, the ratio of distances of the pitot from main wing to mirror wing was 2/.75 = 2.66, while the ratio of the chords was 8/2 = 4, which is in rough accord with the theoretically postulated relationships.

(3) When the mirror wing is well ahead of the pitot its corrective action is too small. As the mirror wing is moved back until its leading edge is a trifle ahead of the pitot nose, its corrective action reaches a maximum. It then overcorrects. As the mirror is moved further back, the corrective action diminishes.

(4) The goal to be reached, namely, that the pitot should give the same reading at both 2° and 15° incidence, as when undisturbed by the presence of the main wing, is apparently best attained when the leading edge of the mirror wing is somewhat behind the nose of the pitot.

(5) Beyond the position of maximum correction, the rate of fall of corrective action as the mirror wing moves back is greater in the high angle of attack than in the low angle of attack. Therefore, it is better to reduce the setting of the mirror wing in relation to the main wing, so as to reduce its corrective action at low incidence.

(6) The "best" position is indicated in Fig. 4. The results obtained with this "best" position are given in Table 1.

TABLE 1

Mirror ¾ in. below Pitot, at −1° to Main Wing, and Leading Edge 2.8 in. Aft of Leading Edge of Main Wing

	at 2°	at 15°
Pitot alone	61 m.p.h.	
Pitot in presence of main wing—no mirror	60.6 m.p.h.	52 m.p.h.
Pitot in presence of main wing—with mirror	61.1 m.p.h.	61.4 m.p.h.

EXPERIMENTS WITH VARYING ASPECT RATIO OF THE MIRROR WING

Experiments were subsequently made with the same two wings, but the aspect ratio of the mirror wing was reduced to 4, 3, 2, and 1. In spite of the use of end plates or shielding fins on the mirror wing, tip vortex effects, and the resultant downwash ruined the effect of the mirror for low aspect ratios. A minimum value of 4 for the aspect ratio of the mirror wing seems desirable.

EXPERIMENTS WITH A LARGER PITOT

When the same combination of main wing and mirror was tested in combination with a much larger Pioneer pitot (provided with a heating coil) insufficient speed adjustment was obtained although the same

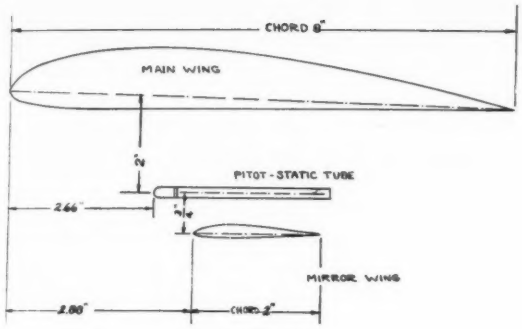


FIG. 4.

tendencies as before were observed. From this it may be inferred that the chord of the mirror wing should bear some relation to the size of the pitot. If the mirror wing is too small in relation to the diameter of the pitot, the extent of the velocity field is too small to produce adequate correction.

EXPERIMENT WITH FLAPS

The main wing used in these experiments is shown in Fig. 5 and was a tapered R.A.F. 48 airfoil with an aspect ratio of 5.25 and a mean chord of 28.2 in. Only the semi-span of the wing (74 in. in length) was used, and a large shielding plate was placed at the widest point of the wing. The same small pitot of $^1/_{16}$ in. diameter as in the earlier experiments was employed. The pitot was mounted at a fixed position at 40 percent of the mean chord (11.28 in.) aft of the leading edge of main wing, and at 25 percent of the mean chord (7.05 in.) below the chord line of the main wing. The spanwise position of the pitot was at 30 percent of the semi-span inboard from the tip. The mirror wing was an R.A.F. 48 airfoil, 9.625 in. in span and with a chord of 1.875 in., rectangular in planform with rectangular tips. The center line of the mirror wing was placed immediately below the axis of the pitot. While the vertical position of the mirror wing was varied, in the experiment reported here the mirror wing was held at $^1/_4$ in. below the pitot. As indicated in Fig. 5 both the main wing and the mirror wing were provided with split flaps. The same adjustments in vertical and horizontal position and in incidence of the mirror wing were available as in the earlier experiments.

In general, the flow below a wing is retarded, but there are wings and regions below the wing where the airstream is actually speeded up. Unfortunately the fixed position selected for the pitot in relation to the main wing was a region of increased air speed at low angle of attack. Therefore the action of the mirror wing with the main wing at low angle of attack was over-corrective and is not reported here. The tests made with the main wing at 12° and the flap depressed through 40° were highly interesting however, and the results are indicated in Fig. 6.

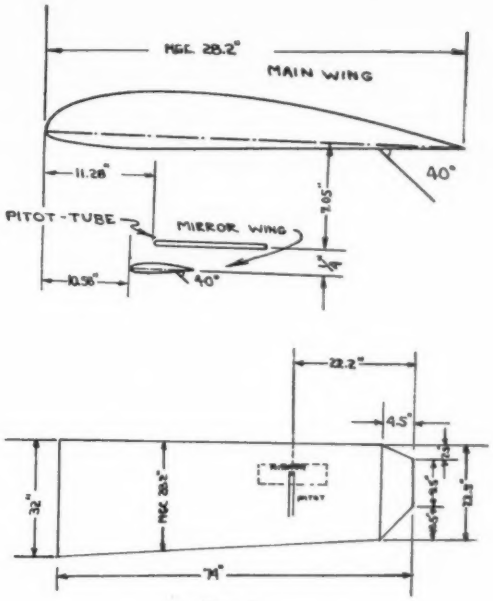


FIG. 5.

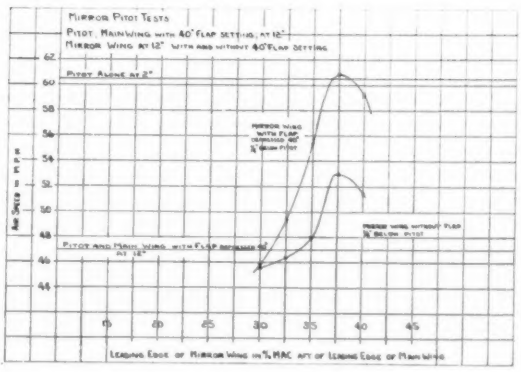


FIG. 6.

In regard to the position of the mirror wing, it was again found that it should have its leading edge in about the same vertical plane as the nose of the pitot.

When the main wing was placed at an angle of attack of 12° and its flap depressed through 40°, the reading of the pitot without assistance from the mirror wing was brought down to the very low value of 47 m.p.h. A large decrease in speed was of course anticipated, since the fundamental action of the split flap is to retard the air ahead of it.

When the mirror wing was in position with its leading edge just a little ahead of the pitot, the corrective action of the mirror wing brought the speed up to 52 m.p.h., still very far from the true value of 60.5 m.p.h.

When the flap on the mirror wing was depressed to 40°, the same as the flap on the main wing, true corrective action was obtained, as can be clearly seen from Fig. 6.

General Conclusions

The experimentation reported here is of course only of a preliminary character, and tests with the mirror pitot in other positions such as above the wing, ahead of the wing, and behind the wing are necessary before a complete evaluation of the device will be possible.

It does not seem likely that the mirror type pitot will ever become a service instrument because of the size and aspect ratio required for the mirror. But it does seem plausible, however, to say that the mirror pitot could well be an addition to flight research or to performance testing.

Without the use of flaps, a position for the ordinary pitot can be found which is moderately satisfactory, but may not be convenient. Therefore, even when flaps are not employed, the mirror might become a useful auxiliary.

When flaps are employed, there is little likelihood of a satisfactory aerodynamic position for the ordinary pitot to meet all the conditions of flight, because many velocity fields are produced. Obviously calibration to meet all these conditions is almost impossible. With the help of the mirror provided with an adjustable flap, correction should be quite easy, and information for the coordination of the main flap and the mirror wing flap could be readily obtained either in the wind tunnel or with one or two simple flight tests.

Moreover, it is fairly clear that if a correct position is found for flight without flap depression, the same position could be maintained for flap depressed flights, with the appropriate coordination mentioned previously between main wing and mirror flaps.

References

[1] Thompson, F. L., *The Measurement of Air Speed in Flight*, Journal of the Aeronautical Sciences, Vol. 4, No. 10, page 423, August, 1937.

[2] Parsons, John F., *Full Scale Wind Tunnel Tests to Determine a Satisfactory Location for a Service Pitot-Static Tube on a Low Wing Monoplane*, N.A.C.A. Technical Note No. 561.

[3] Lapresle, A., *French Wind Tunnel Methods*, Journal of the Royal Aeronautical Society, Vol. 33, No. 226, October, 1929.

Book Reviews

How to Build Flying Boat Hulls and Seaplane Floats, by J. Streeter; Pitman Publishing Corporation, New York, 1938; 90 pages, $2.00.

As described by the author this book is a condensation of working notes and drawings collected over a period of sixteen years. These years were spent on the practical side of aluminum alloy marine aircraft construction.

It does not touch the engineering features of hull or float construction, but describes how the drawings are converted by the shop personnel into the finished product. The book is clearly and simply written and for those not familiar with hull work it leads one by easy stages through the preliminary layout work, the construction of jigs, the building of the detail parts, and the assembly of the final structure. Part I deals with Boat Hulls, Part II with Float Construction, Part III with Repairs. Other parts deal with general shop practice with especial reference to rivets and heat treatment.

One feels that a hull built under Mr. Streeter's supervision would be well built. On the other hand, the assumption is made that the quantities to be made will be small and that hand methods will be used. The assembly jigs for example, are to be made from wood and judging from the excellent drawing would interfere considerably with the accessibility of assembly. Much emphasis is correctly put on the necessity of making jigs and parts accurately, but one gets the impression that the parts are to be made in small lots and fitted on assembly.

The methods described do not take into account the modern trends of metal construction, such as, drop hammers, hydraulic presses, stack sawing, punching, key drilling, etc. A good description is given of the best approved method of hand riveting, but no description of rivet guns, one-shot tools, squeeze, or automatic riveters.

The book contains much good information and the procedure described is undoubtedly sound and according to the best British tradition, but it would be of little value to one faced with the problems of quantity production.

Earl D. Osborn
Edo Aircraft Corporation

Flying Girl, by Elly Beinhorn; Geoffrey Bles, London, 1935, 256 pages, 7s 6d.

For those who are interested in reading of the difficulties and hardships a young woman will endure to see the world, traveling by a small airplane, this book, by a well known German aviatrix will give them the whole picture with added descriptive accounts of what she saw. The urge that prompts girls to take up flying is the same the world over. They suddenly find themselves taken away from a humdrum routine of life and regarded as super-women. They receive chivalrous aid from every male in sight, particularly if they are as attractive as Miss Beinhorn. They receive great publicity which they can often utilize to defray some of their expenses. And, not the least important, they see the world. But this book should serve as a warning that cross-country flying is not to be learned in a few easy lessons over an airdrome. The many times that the engine required overhauling, often without aid from regular mechanics, should convince any young woman, who thinks that she could emulate other famous women fliers, that flying requires more than just moving the joy-stick.

The book will be of particular interest to that better half of our citizens who feel that women can do anything that the other half does. The flight to Timbuctu over West Africa and then from Germany to New Zealand and a final flight from Panama to Buenos Aires, while hardly justifying the subtitle "World Flight," are sufficiently impressive to show that the young German woman has the courage to attempt any kind of a flight. It would also justify her receiving the Harmon Trophy for 1935 as one of the National Champion aviatrixes of Germany.

The Significance of Air War, by E. H. Horne; Marshall, Morgan & Scott, Ltd., London, 1938; 61 pages, 6d.

This odd booklet devotes ninety-nine percent of its space to a study of the Book of Revelation. After a long search the reader found the airplane mentioned once or twice. Its title is a misnomer and was evidently used to attract attention.

A Note on Some Accelerated Boundary Layer Velocity Profiles

ROSCOE H. MILLS, *Georgia School of Technology*

Presented at the Aerodynamics Session, Sixth Annual Meeting, I. Ae. S.
January 26, 1938

SUMMARY

THE present paper deals with the two dimensional equations for the steady flow of a slightly viscous fluid over a flat plate.

The velocity profiles are assumed to be similar for all values of the abscissa x; and writing the velocities within the boundary layer as functions of $(R_y/R_x^{(p+1)/2})$, a separation of variables occurs for all flows whose velocity far from the surface of the plate, U, varies as A/x^p.

The velocity profiles are calculated for the case $p = 1/3$.

An asymptotic expression for the velocity profiles, with p arbitrary, is given. This expression indicates that the velocity profiles are of the type that would occur if the boundary layer were accelerated by injecting additional fluid into the flow.

An expression for the variation of the local coefficient of skin friction with Reynolds Number is also given, that is $C_f = 2aR_x^{(p-1)/2}$.

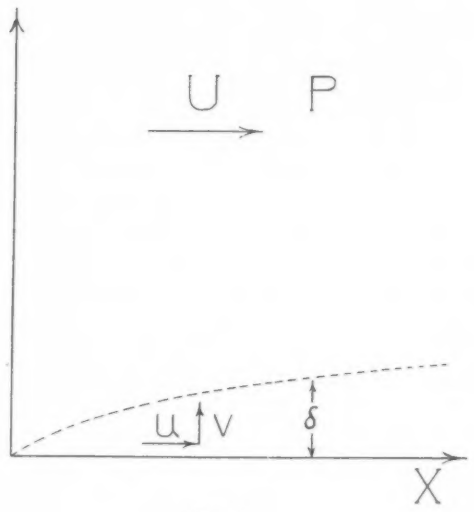


FIG. 1.

THE BOUNDARY LAYER EQUATIONS

Consider the laminar boundary layer equations[1] for the two-dimensional steady flow of a slightly viscous fluid over a flat plate

$$u(\partial u/\partial x) + v(\partial u/\partial y) = \nu(\partial^2 u/\partial y^2) - \frac{1}{\rho}(\partial P/\partial x) \quad (1)$$

$$\partial P/\partial y = 0 \quad (2)$$

and the equation of continuity

$$(\partial u/\partial x) + (\partial v/\partial y) = 0 \quad (3)$$

where U denotes the velocity in the x direction at a great distance from the plate; u and v the velocities within the boundary layer in the x and y directions, respectively; P the pressure; ν the kinematic coefficient of viscosity; and ρ the fluid density (Fig. 1).

Assume that the flow in the immediate neighborhood of the plate is essentially parallel to the plate, and that the velocity U in the potential flow far from the plate varies as some power of x, that is, write $U = A/x^p$. Also, assume that the velocity profiles in the boundary layer are similar for all values of x; thus $u = Uf(y/\delta)$, where δ is the boundary layer thickness at x. Assume δ proportional to x^n. Then the boundary layer velocity $u = (A/x^p)f(yB/x^n)$, where A has the dimensions of a velocity times a (length)^p, and B has the dimensions of a (length)$^{n-1}$. As a length characteristic of the flow choose ν/V, where V is the value of U at x equal to unity. Writing $R_y = Vy/\nu$, $R_x = Vx/\nu$, and a stream function $\psi = (A/x^p)[R_x^n/(V/\nu)]h(\theta)$, where $\theta = R_y/R_x^n$; the velocities u and v become

$$u = (A/x^p)h'(\theta)$$

$$v = (A/x^{p+1})[R_x^n/(V/\nu)][n\theta h'(\theta) + (p - n)h(\theta)]$$

Eq. (2) indicates that the pressure is constant through the boundary layer, and hence the value $(1/\rho)(\partial P/\partial x)$ can be obtained from the variation of pressure with x in the potential flow. Bernoulli's theorem gives $(1/\rho)(\partial P/\partial x) = pA^2/x^{2p+1}$.

Substituting these values for u, v, and $(1/\rho)(\partial P/\partial x)$ into Eq. (1), a separation of variables occurs if $p = 2n - 1$, and Eq. (1) reduces to the ordinary differential equation*

$$\frac{\nu}{A}\left(\frac{\nu}{V}\right)^{p-1} h'''(\theta) + \frac{1-p}{2} h''(\theta)h(\theta) + p[h'(\theta)]^2 - p = 0 \quad (4)$$

* Primes refer to the derivative with respect to the independent variable.

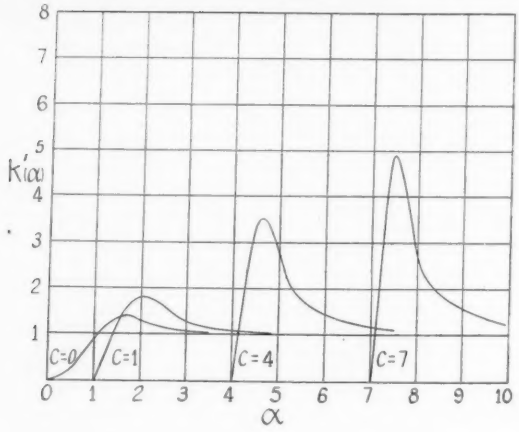


FIG. 2.

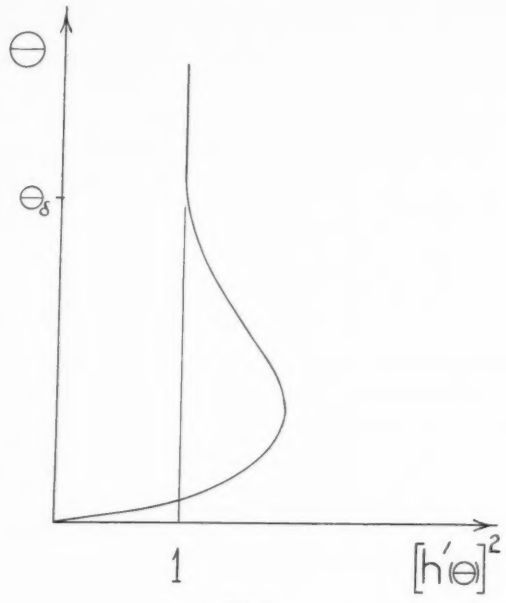


FIG. 3.

SPECIAL CASES OF EQ. (4)

Case 1

For $p = 0$; $U = V = A$ and Eq. (4) becomes

$$h'''(\theta) + h''(\theta)h(\theta)/2 = 0 \tag{5}$$

This is the equation Blasius[2] solved when considering the case of laminar flow, without pressure drop, along a flat plate.

Case 2

For $p = 1$; $U = A/x$ and Eq. (4) is

$$(\nu/A)f''(\theta) + f^2(\theta) - 1 = 0 \tag{6}$$

where $f(\theta) = h'(\theta)$.

This differential equation arises in the case of the flow of a viscous fluid between inclined walls.[3]

Case 3

For $p = 1/3$; $U = A/x^{1/3}$ and Eq. (4) becomes

$$\frac{\nu}{A}\left(\frac{V}{\nu}\right)^{2/3} h'''(\theta) + \frac{1}{3}h''(\theta)h(\theta) + \frac{1}{3}[h'(\theta)]^2 - \frac{1}{3} = 0 \tag{7}$$

An equation of this type occurs in the problem of the radial flow of a viscous fluid over an infinite circular disc.[4]

Integrating twice and writing $k(\alpha) = gh(\theta)$, where $\alpha = g\theta + c$, $c = 3a_1g$, $g = \sqrt{(A/6\nu)(\nu/V)^{2/3}}$ and "a_1" is an integration constant; Eq. (7) becomes

$$k'(\alpha) + k^2(\alpha) = \alpha^2 - c^2 \tag{7a}$$

A solution is $k(\alpha) = \eta'(\alpha)/\eta(\alpha)$, where $\eta(\alpha) = E_m(\alpha)\left[\beta + \gamma\int_c^\alpha \frac{d\alpha}{E_m^2(\alpha)}\right]$, $E_m(\alpha)$ being a normalized Hermite polynomial of order m.

An asymptotic expression for the velocity profiles is easily obtained from the boundary condition at infinity, that is $u/U = k'(\alpha) = 1 + (c^2 + 1)/2\alpha^2$.

Defining the local friction coefficient as $C_f = \tau_0/(\rho U^2/2)$, where $\tau_0 = \mu(\partial u/\partial y)_0 = \mu U[dk'(\alpha)/d\alpha]_c(\partial\alpha/\partial y)$ is the shearing stress at the plate, $C_f = 2a_1R_x^{-1/3}$.

The velocity profiles have been calculated by a numerical integration of Eq. (7a), Fig. 2, and have the shape one would expect to find if the flow in the boundary layer were accelerated by injecting fluid into the flow at the surface of the plate.

Although the general solution to Eq. (4) is not known to the author, it is possible to make an observation as to the variation, with R_x, of the local friction coefficient for various pressure drops; also a remark as to the nature of the velocity profiles.

EXPRESSION FOR THE FRICTION COEFFICIENT

Consider Eq. (4); add and subtract $(1 - p)/2 \times [h'(\theta)]^2$ and integrate once.

$$\frac{\nu}{A}\left(\frac{\nu}{V}\right)^{p-1} h''(\theta) + \frac{1-p}{2}h'(\theta)h(\theta) + \frac{3p-1}{2}\int_0^\theta [h'(\theta)]^2 d\theta = p\theta + a \tag{8}$$

The boundary conditions for a viscous fluid require that at $\theta = 0$, $u = v = 0$, that is, $h(\theta) = h'(\theta) = 0$. Therefore $h''(\theta) = a/(\nu/A)(\nu/V)^{p-1}$ and the local friction coefficient is $C_f = 2aR_x^{(p-1)/2}$

ASYMPTOTIC EXPRESSION FOR THE VELOCITY PROFILES

On integration Eq. (8) becomes

$$\frac{\nu}{A}\left(\frac{\nu}{V}\right)^{p-1} h'(\theta) + \frac{1-p}{4}h^2(\theta) + \frac{3p-1}{2}\int_0^\theta\left\{\int_0^\theta [h'(\theta)]^2 d\theta\right\} d\theta = \frac{p\theta^2}{2} + a\theta + b \tag{9}$$

and as at $\theta = 0$, $h(\theta) = h'(\theta) = 0$; $b = 0$.

The boundary condition at ∞ requires that as $\theta \longrightarrow \infty$, $u/U = h'(\theta) \longrightarrow 1$.

Consider $\int_0^{\theta \to \infty} [h'(\theta)]^2 d\theta$ (refer to Fig. 3) for any real flow the effect of viscosity will be noticeable only for a finite distance from the plate, to θ_δ say, then

$$\int_0^{\theta \to \infty} [h'(\theta)]^2 d\theta = \int_0^{\theta \to \infty} (1) d\theta - \int_0^{\theta_\delta} \left\{1 - [h'(\theta)]^2\right\} d\theta \doteq \theta + D \text{ and}$$

$$\int_0^{\theta \to \infty} \left\{\int_0^{\theta \to \infty} [h'(\theta)]^2 d\theta\right\} d\theta \doteq (\theta^2/2) + D\theta$$

where $$D = \int_0^{\theta_\delta} \left\{1 - [h'(\theta)]^2\right\} d\theta$$

Substituting this approximation for the integral into Eq. (9), and writing $h'(\theta) = 1$

$$h(\theta) = \theta \left(1 + \frac{2M}{\theta} - \frac{4N}{\theta^2}\right)^{1/2}$$

where $M = (2a + (1 - 3p)D)/(1 - p)$

and $$N = (\nu/A)(\nu/V)^{p-1}/(1 - p)$$

Expanding the parentheses and neglecting terms of the order of $1/\theta^3$ and higher, one obtains

$$h(\theta) = \theta + M - \left(2N + \frac{M^2}{2}\right) \cdot \frac{1}{\theta} \qquad (10)$$

and

$$h'(\theta) = 1 + \left(2N + \frac{M^2}{2}\right) \cdot \frac{1}{\theta^2} \qquad (11)$$

as asymptotic expressions for $h(\theta)$ and $h'(\theta)$.

Again there occur velocity profiles that approach the free-stream velocity from a region of higher velocity than that in the potential flow. Also it is noted that this type of profile occurs irrespective of the sign of D.

Conclusions

It would thus appear that stable laminar velocity profiles might be obtained if the boundary layer were accelerated by injecting additional fluid into the flow, excepting flows where the velocity in the free stream decreases proportional to $1/x$; that is, the case $p = 1$. Probably all cases where p is close to one would also have to be excepted.

References

[1] Dryden, Hugh L., Murnaghan, Francis D., Batemen, H., *Hydrodynamics*, page 253. Bulletin No. 84 of the National Research Council of the National Academy of Sciences, Washington, D. C., February, 1932.

[2] *Ibid.*, page 260.

[3] *Ibid.*, page 263.

[4] Mills, R. H., *The Boundary Layers for Some Axially Symmetric Flows*, Thesis, California Institute of Technology.

Book Review

An Introduction to Aeronautical Engineering, Vol. 1, Mechanics of Flight, by A. C. Kermode; Sir Isaac Pitman & Sons, Ltd., London, 1937; 197 pages, $2.50.

The set consists of three volumes; Vols. 2 and 3, by J. D. Haddon, are entitled "Structures" and "Properties and Strength of Materials," respectively. The books are designed to "appeal equally to draughtsmen, apprentices, pilots, and students of technical schools who are desirous of entering some kind of aeronautical work."

Vol. 1 comprises eight chapters, dealing with The Atmosphere, Air Resistance, Airfoils, Horizontal Flight of the Airplane, Maneuvers, Stability and Control, The Airscrew, and Our Airplane. An introduction takes up the nomenclature of the parts of an airplane. The book is, for the most part, well written and few equations are used; wherever possible they are supplanted by graphs. This reviewer feels, however, that the chapter on Air Resistance, a 33 page discussion of wind-tunnel testing, scale effect, wall interference, resistance, units, etc., contains too many new concepts to be readily assimilated. This is not a serious defect considering the object of the book. If the reader's interest is sustained until toward the end of the second chapter he will in all probability finish the book and gain a good idea of the principles of flight, the intereaction between the forces acting on an airplane in level flight and during maneuvers, stability and the general characteristics of propellers.

The value of the book as a text is considerably enhanced by a list of questions at the end of each chapter and a list of general questions and over a hundred numerical problems at the end of the book.

Arnold M. Kuethe

Books Received

Those "Senor Letters," by C. A. Van Dusen; Pan American Airways, New York, 1937; 113 pages.

Vier Jahre Sozialer Aufbau, Junkers Flugzeug-und-Motorenwerke A. G., 88 pages, ill.

Institute Notes

A New Award for Gliding

The Octave Chanute Gliding Award has been established to be presented annually to an American who has made an outstanding contribution to the art or science of flight without power. The Committee for the selection of the recipients for the award will be:

Major General O. Westover, Chief of the Air Corps, War Department.

Rear Admiral A. B. Cook, Chief of the Bureau of Aeronautics, Navy Department.

Dr. Lyman J. Briggs, Director of the National Bureau of Standards.

Dr. G. W. Lewis, Director of Research of the National Advisory Committee for Aeronautics.

Denis Mulligan, Director of Air Commerce, Department of Commerce.

T. P. Wright, President of the Institute of the Aeronautical Sciences.

Major Lester D. Gardner, Secretary of the Institute of the Aeronautical Sciences.

The last named will serve as Secretary of the Committee.

It is hoped that this award may be endowed so that a $250 check may be presented with the certificate as is done with the Sylvanus Albert Reed Award and the Lawrence Sperry Award.

Visitors

The following foreign guests have recently visited the Institute. L. C. Tombs, of the Secretariat, League of Nations, Geneva, Switzerland; N. Eraslan, Turkish Trials Commission, Istanbul, Turkey; Robert Arnold Hall, British Airways, Ltd., London, England; Prof. Ed. Amstutz, Swiss Federal Institute of Technology, Zurich, Switzerland; Henry Pillichody, Technical Manager Swissair, Zurich, Switzerland; The Earl of Cottenham, London, England; Dr. Ing. Georg Madelung, Professor, Technische Hochschule, Stuttgart, Germany; Dr. Ing. Werner Wenzel, Junkers Flugzeug-und-Motorenwerke A. G., Dessau, Germany; Lieut. Col. Andrzej Chramiec, Military Attache, Embassy of Poland, Washington; Lawrence A. Wingfield, Clerk to the Guild of Air Pilots and Navigators, Hon. Solicitor to the Royal Aeronautical Society, London, England; A. H. R. Fedden, Hon. Fellow I. Ae. S., Technical Director and Chief Engineer, Bristol Aeroplane Company, Ltd., Bristol, England; F. M. Owner, Assistant Design Engineer, Bristol Aeroplane Company, Ltd., Bristol, England.

Lecture by P. V. H. Weems

A meeting of the New York branch of the Institute was held on May 24. Lieut. Commander P. V. H. Weems of the Weems System of Navigation, Annapolis, Maryland, gave an interesting lecture on "Avigation Methods and Equipment." The lecture dealt with the advantages and disadvantages of celestial avigation as compared with radio, and a description of the methods and instruments used in celestial avigation. The various instruments, by means of which bearings can be taken in a comparatively short time, where illustrated by lantern slides. Many interesting anecdotes emphasized the various points brought out by the speaker.

The lecture and accompanying slides will be available in the near future for presentation at Institute branches.

Wednesday Luncheons

As in the past, regular Wednesday luncheons of the Institute, at which pertinent topics are informally discussed, are being held. On March 23 the subject "Assisted Take-Offs" was discussed, and, on March 30, James B. Taylor told of his experiences in flying a Tailless Airplane. A general discussion of "Plastics" was held on April 6, and, on April 13, Ray Quick spoke on "Large Flying Boats." Major Lester D. Gardner described his "Yucatan Loop Flight" on April 20, and, on April 27 Prof. Georg Madelung of the Technische Hochschule of Stuttgart spoke on "German Aviation." On May 4, Col. J. Carroll Cone of Pan American Airways spoke on "Transatlantic Flying."

Student Branches

University of Michigan. Two meetings of this Student Branch of the Institute were held during the month of April. At the first, held on April 21, the motion pictures of "A Visit to Langley Field" were shown. About 200 persons attended the meeting. Following the showing of the motion pictures, a business meeting was held at which a competition for student papers was discussed, and tentative plans were made for a trip to the Curtiss-Wright plant in Buffalo.

On Saturday, April 23, about 30 members of this Student Branch made a trip to the Stinson Aircraft plant at Wayne, Michigan, and the Wayne County Airport.

At the second meeting, held on April 28, the motion pictures of the "European Aeronautical Laboratories" were shown. A business meeting was held after the showing of the films to elect officers for the coming year. The following officers were elected: Max Sokol, Chairman; Edward Kurzawa, Secretary; John Reeder, Treasurer; and Julius Jaeger, Engineering Council Representative.

North Carolina State College. The final meeting of the school year of this Student Branch was held on Tuesday, May 17. Election of officers for the next school year was held and the following were elected: J. T. Bower, Chairman; Robert Loos, Vice-Chairman; C. Moseely, Secretary; and F. Abbott, Treasurer.

Rensselaer Polytechnic Institute. A business meeting of this Student Branch was held on May 11, at which the following officers for the 1938–39 term were elected: H. B. Williams, President; Robert Wells, Vice-President; J. C. Luttrell, Treasurer; and J. W. Miller, Secretary.

Necrology

Henry Webb Salisbury

Henry Webb Salisbury, a Technical Member of the Institute, Mrs. Salisbury, and their two children were killed in an airplane crash near Burbank, California on May 17, 1938. Mr. Salisbury was born in Syracuse, New York, on Oct. 5, 1908. He studied Aeronautics at the Massachusetts Institute of Technology, receiving a Master of Science degree, with distinction, in 1933.

Mr. Salisbury was formerly Instructor in Aeronautical Engineering at the University of Minnesota. At the time of his death he was Assistant to the Vice-President in charge of Operations for Northwest Airlines. He was an Ensign in the U. S. Naval Reserve.

Exchanges

The Institute exchanges the Journal with many other aeronautical periodicals. They are kept on file at the Skyport in Rockefeller Center, New York City, where members may read them. As readers of the Journal may wish to subscribe to some of them, a list of these periodicals with their addresses is published here. Information regarding subscription prices may be secured from the Secretary of the Institute.

Aero, Maneesikatu 2, Helsingfors, Finland.

Aero Digest, 515 Madison Ave., New York City.

Aeronautica Argentina, Velez Sarsfield 57, Cordoba, Argentina.

L'Aéronautique, 55 Quai des Grands-Augustins, Paris, France.

L'Aérophile, 7 Rue Sainte-Lazare, Paris, France.

The Aeroplane, 175 Piccadilly, London, W.1, England.

L'Aerotecnica, Via delle Coppelle 35, Rome, Italy.

Les Ailes, 77 Boulevard Malesherbes, Paris, France.

Aircraft Engineering, 2 Bloomsbury Place, London, E.C.1, England.

Air Law Review, Washington Square East, New York City.

American Aviation, Earle Building, Washington, D. C.

Asas, Caixa Postal 1967, Rio de Janeiro, Brazil.

Astronautics, American Rocket Society, 31 West 86th Street, New York, N. Y.

Aviation, 330 West 42nd St., New York City.

L'Aviazione, Corso Umberto 504, Rome, Italy.

Boletin de Aeronautica Civil, Calle Azcuenga 923, Buenos Aires, Argentina.

Bulletin du Service Technique de l'Aéronautique, 72 Chaussee de Waterloo, Rhode-Saint-Genese, Belgium.

Bulletin of the American Meteorological Society, Blue Hill Observatory, Milton, Massachusetts.

Bulletin Officiel du R.A.A., 6 Rue du Mezieres, Paris (6), France.

Bulletin Technique du Bureau Veritas, 31 Rue Henri-Rochfort, Paris (17), France.

Canadian Aviation, Journal Building, Ottawa, Canada.

Contact, Fort Lee, N. J.

Deutsche Luftwacht, Schoeneberger Ufer 46, Berlin W35, Germany.

Der Deutsche Sportflieger, Peterssteinweg 19, Leipzig C1, Germany.

Les Fiches Aéronautiques, 6 Rue Galilee, Paris, France.

Flight, Dorset House, Stamford St., London, S.E.1, England.

Flugwesen, Konviktska 22, Prague 1, Czechoslovakia.

Indian Aviation, P. O. Box 2361, Calcutta, India.

Interavia, 13, Corraterie, Geneva, Switzerland.

Journal of Air Law, Northwestern University, Chicago.

Journal of the Institute of Engineers, Australia, Science House, Gloucester and Essex Sts., Sydney, N. S. W., Australia.

Journal of Research of the National Bureau of Standards, U. S. Govt. Printing Office, Washington, D. C.

Journal of the Royal Aeronautical Society, 7 Albemarle St., Piccadilly, London, W.1, England.

Journal of Scientific Instruments, 1 Lowther Gardens, Exhibition Rd., London, S.W.7, England.

Journal of the Society of Automotive Engineers, 29 West 39th St., New York City.

L'Ala d'Italia, L'Aquilone, La Rivista di Diritto Aeronautico, La Rivista di Meteorologia Aeronautica, Le Vie dell'Aria, Viale dell'Universita 4, Rome, Italy.

Letectvi, Celetna 13, Praha I, Czechoslovakia.

Luftfahrt-Forschung, Verlag Oldenbourg, Munich 1, Germany.

Die Luftreise, Lindenstr. 35, Berlin SW68, Germany.

Luftfahrt-Literaturschau, Z.W.B. bei der D.V.L., Berlin-Adlershof, Germany.

Model Airplane News, 551 Fifth Avenue, New York City.

Model Aviation, The American Academy for Model Aeronautics, 1733 RCA Building, Rockefeller Center, New York, N. Y.

Monthly Weather Review, U. S. Dept. of Agriculture, Washington, D. C.

Motor and Flying, 24 Bond St., Sydney, N. S. W., Australia.

National Aeronautic Magazine, Dupont Circle, Washington, D. C.

Official Aviation Guide, 608 S. Dearborn St., Chicago, Illinois.

The Pilot, Grand Central Air Terminal, Glendale, California.

Il Politecnico, Via Spiga 32, Milan (2/7), Italy.

Popular Aviation, 608 S. Dearborn St., Chicago, Illinois.

Proceedings of Institute of Radio Engineers, 330 W. 42nd St., New York City.

Publications Scientifiques et Techniques du Ministère de l'Air, 55 Quai des Grands-Augustins, Paris, France.

Review of Scientific Instruments, 175 Fifth Ave., New York City

Revue de l'Armée de l'Air, 55 Quai des Grands-Augustins, Paris, France.

Revue du Ministère de l'Air, 71 Avenue des Champs-Elysees, Paris (8), France.

Rivista Aeronautica, Ministero dell'Aeronautica, Rome, Italy.

The Royal Air Force Quarterly, Gale & Polden Ltd., 2 Amen Corner, London, E.C.4, England.

Schweizer Aero-Revue Suisse, Gubelhangstrasse 22, Zürich-Oerlikon, Switzerland.

Soaring, 1614 Delaware Ave., Wilmington, Del.

Southern Flight, Ledger Building, Fort Worth, Texas.

Sportsman Pilot, 515 Madison Ave., New York City.

Technical News Bulletin of the National Bureau of Standards, U. S. Govt. Printing Office, Washington, D. C.

Technika Lotnicza, Czerwonego Kryza 21/23 m.6, Warsaw, Poland.

Technika Vosdushnogo Flota, U1. Radio 16, Moscow 16, U. S. S. R.

La Technique Aéronautique, 2 Rue Blanche, Paris (9), France.

U. S. Air Services, Transportation Building, Washington, D. C.

Western Flying, 420 S. San Pedro St., Los Angeles, California.

Wirtschaft Technik Verkehr, Alte Jakobstr. 148/155, Berlin, SW68, Germany.

Zeitschrift für angewandte Mathematik und Mechanik, Kulmstr. 1, Dresden A24, Germany.

AERONAUTICAL REVIEWS

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here each month by permission of the Chief of the Air Corps.

Aerodynamics

Calculation of the Lift Distribution on Wings. H. Multhopp. Method described has been used in Germany at various experimental stations as well as in the industry. The calculation is limited to the solution of a continually iterative equation system and progressive development or harmonic analysis is not necessary. The method is also applicable where lift is no longer a linear function of the angle of attack. This makes it possible to apply the measuring results obtained to complicated wing types under greatly simplified conditions. Report of the Goettingen Aerodynamic Institute. Luftfahrtforschung, April 6, 1938, pages 153–169, 9 tables, 81 equations.

Model of Calculation for Computing Lift Distribution over the Wing Span According to the Multhopp Method. M. Schwabe. For facilitating the application of the method developed by H. Multhopp in the preceding article, a scheme of calculation is given which is applicable only in the field of linear dependence of lift on angle of attack. DVL report. Luftfahrtforschung, April 6, 1938, pages 170–180, 8 illus., 17 tables, many equations.

Motion Pictures Taken Simultaneously from Three Perpendicular Directions of a Bird in Flight. H. Girerd. Test method developed for taking motion pictures of a bird in flight, three perpendicular views being recorded simultaneously on one film. Equipment is described in detail, and results obtained in a study of the motion of a bird during beating of the wings are discussed. The author shows why the anatomy of the bird is not sufficient to explain the form of the beating and uses the Lilienthal polar to explain the encirclement of birds. Drawings and many three-view photographs are included. L'Aéronautique, February, 1938, pages 31–39, 11 illus.

The Manipulation of the Boundary Layer. E. G. Richardson. Various methods employed in research in the past ten years to alter—for better or worse—the conditions in the boundary layer of a body in turbulent flow, including methods of accelerating, heating and periodically oscillating the boundary layer. The author describes his research with Dr. Tyler on "synthetic turbulence" in which they studied the effect of transmitting periodic waves into a pipe from a section of the wall which was given a small simple harmonic motion parallel to direction of flow. This form of artificial turbulence was tried in the flow past a streamlined strut and a circular cylinder. Royal Aeronautical Soc., Preprint for Meeting, April 7, 1938, 18 pages, 18 illus.

Profile Drag Measurements in the Large Wind Tunnel at the D.V.L. H. Doetsch and M. Kramer. State of the research work being done on the question of profile drag at high speeds in the 16.5×23-ft. wind tunnel of the D.V.L. Profile drags of the NACA 24 series for thickness from 9 to 21 percent of the chord are from 18 to 35 percent less than those measured in the NACA pressure tunnel. Seriously adverse effects of gaps between wings and flaps, and of waviness in the surface, notably the undersurface of a wing, are shown. Full translation from Luftfahrtforschung, Vol. 14, No. 4/5. Aeroplane, April 6, 1938, pages 421–425, 9 illus.

Aircraft Design

Aircraft Efficiencies. N. A. V. Piercy. Increased wing loadings; effect on aerodynamic efficiency of reduced aspect ratio for large fast aircraft and in increasing speed range from $3^1/_2$ to 4; M. Jones' method of calculating efficiency which does not make allowance for form drag due to thickness of bodies, wings, etc.; outstanding engine matters; and conclusions. Concluded. Institution of Mechanical Engineers paper. Engineering, April 15, 1938, page 433, 2 tables, 2 equations. Engineer, April 1, 1938, pages 374–376, 3 illus., 1 table, 11 equations.

Influence of Propeller Slipstream on Wings and Tail Surfaces. J. Stueper. Wind-tunnel measurements taken to determine slipstream effect on lift and downwash of a wing. Influence of a jet without spiral effect and with constant velocity distribution was determined. Three-component, pressure-distribution and downwash measurements were taken and results compared with theoretical estimates. The stream produced an increase in lift. Downwash measurements at the tail showed an increase of downwash angle due to the stream.

Second part of the report is devoted to the influence of the propeller slipstream, the slipstream axis being fixed in the initial direction of flow. The spiral and the dynamic pressure change in the stream caused an unsymmetrical change of lift. From the downwash ratio it was found that the stream cut into two parts by the wing does not join again behind the wing, and especially that each part in the direction of the slipstream rotation experiences a lateral deviation.

Measurements with the propeller axis inclined to the wing chord, discussed in the third section, showed an important influence on the change of lift on the wing due to the propeller slipstream. Report of Goettingen Aerodynamic Institute. Luftfahrtforschung, April 6, 1938, pages 181–205, 85 illus., 3 tables, many equations.

Sliding and Sweptback Wings. J. Hueber. Corrections to article by F. Weinig appearing in Vol. 14 (1937) No. 2, pages 45–54. Luftfahrtforschung, April 6, 1938, pages 213, 218, 3 illus.

Calculation Sheets for Airplane Design. B. Goethert. Relations are derived and represented in diagrams for determining, for any airplane and condition of flight, the influence of a change of frontal resistance, gross weight, engine performance, propeller efficiency, altitude of flight, wing aspect ratio and wing size on the maximum speed, rate of climb and ceiling. Concluded. DVL report. Luftwissen, February, 1938, pages 46–48, 3 illus., 6 tables, many equations.

Interference Effects in Relation to Longitudinal Static Stability. A Klemin and E. B. Schaefer. Pitching moments were measured on a model of the high-speed monoplane "Time Flies" when the airfoil was located in the midwing position and when in the neutral position both with fillet increasing in radius from leading to trailing edge and with a constant-radius fillet. Tail surfaces were above the extended chord line of the wing. Measurements made on a model of a twin-engined low-wing monoplane designed by D. de Lackner showed that, in addition to changing position and fairing of the nacelles, the most effective method of remedying interferences is to raise the stabilizer surface. Wind-tunnel test results. Aero Digest, April, 1938, pages 29–30, 5 illus.

Strength of Wooden Spars. J. H. Payne. In a previous installment an idealized stress-strain diagram for spruce was used to obtain the strength of spars of solid rectangular section for any combination of end load and bending moment. In this installment the same assumptions are applied to an I-section or box-section beam in which the web or webs are relatively thin and serve mainly to carry shear loads. Resistance of such a beam to bending is considered to be provided entirely by the flanges. Continued. Flight, Aircraft Engr. Sup., April 21, 1938, pages 25–26, 4 illus., 5 equations.

Showing the Way. Lockheed hydraulic equipment has been chosen to operate the colossal retractable undercart and undercarriage doors on the new A. W. Ensign airliners built for Imperial Airways. Short note and photograph of wheel and its retracting gear. Aeroplane, April 20, 1938, page 487, 1 illus.

The Tricycle Undercarriage. G. T. R. Hill. Advantages and disadvantages of tricycle landing gear. Past history is reviewed and design considerations are discussed including: Development of conventional type of landing gear; central track landing gear development of tricycle undercarriages; varieties of landings claimed; early reduced-incidence schemes; braking; take-off; directional stability; castor-wheel shimmy; installation, weight and cost; and limitation of elevator movement. Aircraft Engineering, April, 1938, pages 95–98, 9 illus.

Strength and Design Problems in the Production of All-Metal Airplanes in Large Quantities. F. Griebsch. Problems in airplane construction; extent of finishing and quality; construction in regard to fundamentals of design, load that develops, materials and structural elements; and rules for design. Luftwissen, February, 1938, pages 41–45, 10 illus.

The Strength of Wooden Spars. J. H. Payne. Design stresses laid down by the U. S. Department of Commerce, and depending upon cross section of the spar, ratio of bending stress to end compression stress, and slenderness ratio; Prager's method of obtaining allowable bending stress, taking account of the spar cross section; tests wanted to confirm the actual value of strain at failure; two types of failure with end load and bending moment increased progressively; and the proof factor requirement. To be concluded. Flight, Aircraft Engr. Sup., March 31, 1938, pages 21–23, 5 illus., 2 tables, 9 equations.

Tubular Mono-Spars. R. Vogt. Different types of wing construction are compared and reasons given for adoption of the tubular spar wing. This is a real single-spar wing where torsion-carrying fibers are combined with the bending member. Center-section "cranked" spar in welded steel, the spar acting as a fuel tank, and fittings welded to the spar of the Hamburger Ha-139 are illustrated. Relatively simple construction and use of the spar as a jig during construction are discussed. Flight, Aircraft Engr. Sup., March 31, 1938, pages 19–20, 7 illus.

Wing Structures with Tubular Spars. R. J. Margoulis. Application of the Vogt system to the Hamburger Ha-139 transatlantic flying boat. L'Aéronautique, February, 1938, pages 27–30, 6 illus.

Engineering Aspects of Commercial High Altitude Flying (With Particular Reference to Recent Development in the United States). J. E. Younger. Research on pressure cabins carried out by the Air Corps; types of structure suitable for a pressure cabin; elastic expansion and ultimate strength factors; sealing of joints against air leakage; expansion of cabin skin under pressure; probability of explosion of pressure cabin; bulkheads; strength of glass windows; cabin doors and emergency exits; glands for control wires and tubes to control surfaces and engines; outward and inward pressure safety valves; silencing airflow noises; pressure-cabin discharge valves; regulation of airflow into pressure cabin; automatic sealing of cabin and release of oxygen spray in case of failure of superchargers; control of icing and frosting of windows; frosting of exposed metals on the inside of the cabin, and heat insulation; utilization of dynamic air pressure and energy of air discharged from the cabin; cabin pressure required; cleaning and conditioning air; supercharging requirements; and fuel supply problems. Royal Aeronautical Soc., Preprint for Meeting, April 21, 1938, 23 pages, 17 illus.

Operating Characteristics of Large Flying Boats. W. K. Ebel. Operating conditions; water-handling problems, including trends toward use of increased beamloadings, with relatively narrow hulls and reduced front areas, porpoising, and directional controllability at high water speeds; outstanding problems encountered in purely flying operation; Glenn Martin Company method of testing a flying scale model of a projected large flying boat design; seaworthiness problems; and comparative statistics on the N.C. boats and the Martin 156. S.A.E., Preprint for Meeting, March 10–11, 1938, 10 pages, 2 tables.

Science and the Future of Aviation. I. I. Sikorsky. An altitude of from 75,000 to 90,000 ft. and a speed of from 500 to 600 m.p.h. probably will not be exceeded until a new source of energy giving greater power per unit of weight, combined with a new method of propulsion becomes available. Flying boats of 500 or 1000 tons carrying several thousand passengers could be successfully designed and built, but a larger number of ships of 100 to 250 tons with frequent departures would render better service and will remain the backbone of the intercontinental flying fleet during the next five years. Limitations to speed, altitude and size of aircraft, as well as advantages of high-altitude flight are discussed. Electrical Engineering, April, 1938, pages 149–153, 4 illus., 1 table.

Wind-Tunnel Tests on Strut Intersection Points. M. Kohler. Force measurements show that the drag of strut intersection points can be considerably lowered by use of suitable fairing. By means of the arrangement of a main strut with a vertically mounted side strut having an elongation of the profile of the main strut but of a larger width and a channel, the effect of reciprocal interference can be isolated. Total pressure measurements behind a few strut intersection points give data concerning the expansion and nature of the disturbed area. Report of the Goettingen Aerodynamic Institute. Luftfahrtforschung, April 6, 1938, pages 143–152, 18 illus., 13 tables.

Stress Analysis and Structures

Bending Stresses in Box Beams as Influenced by Shear Deformation. P. Kuhn. History of the box-beam problem is traced and the problem of redistribution of bending stresses caused by shear deformation on the cover sheet is considered. Solutions for special cases are combined into a method of analysis for box-beam wings. With the help of analytical formulas for a simple case, various structural arrangements of a small transport-size wing are compared. Numerical values given for each case show the error intro-

duced by using ordinary bending theory and also show how much extra weight is required to make up for the inefficiency caused by shear deformation. S.A.E. Preprint for Meeting, March 10–11, 1938, 15 pages, 9 illus., 1 table, 4 equations.

Balance Calculations. W. Wilson. Balance calculations for certain flight conditions which are used in determining loads for calculating the strength of the aircraft structure, especially of the wing structure. Alternative method to those given in the British Air Publications 970 and 1208 is described for which greater simplicity is claimed. Flight, Aircraft Engr. Sup., April 21, 1938, pages 27–29, 4 illus., 2 tables, 7 equations.

The Effect of Pressure Upon the Elastic Parameters of Isotropic Solids, According to Murnaghan's Theory of Finite Strain. F. Birch. Murnaghan's theory of finite deformations is applied to a discussion of the effect of hydrostatic pressure upon the elastic coefficients of an isotropic body, for small strains superposed on the hydrostatic strain. Stress-strain equations for small strains and equations of small motion are shown to have the same form as those of the classical theory, with elastic parameters which depend upon the pressure. By use of a form of elastic potential identical with that of the classical theory, explicit results are found for the pressure coefficients of compressibility, Young's modulus of rigidity and so on, which are in good agreement with experimental results. Jour. Applied Physics, April, 1938, pages 279–288, 4 tables, 15 equations.

Elastically Encastré Struts. F. G. R. Cook and W. Tye. Suggestion for the stressing of members subject to end restraint. A method is developed for estimating the bending moment at any point in an initially bowed strut under known end load with any condition of restraint. It is shown that the equation obtained can be represented graphically by means of a polar diagram. Aircraft Engineering, April, 1938, pages 103–104, 106, 4 illus., 10 equations.

Instability of Monocoque Structures in Pure Bending. N. J. Hoff. Flattening and local buckling are discussed in detail, and applicability of the results to practical fuselages of noncircular cross section as well as effects of the different neglections are considered. Theoretical and experimental results obtained by various authors in regard to both load-carrying capacity of panels after buckling, and failure of stringers are reviewed. Flattening of monocoque structures, and the local buckling of these structures are explained. Experiments are described which indicated that local buckling involves simultaneous buckling of several stringers and several rings on the compression side of the bent structure. With the aid of the diagrams given the possibility of the occurrence of local buckling may be conveniently checked in any practical case. Very long article. Jour. Royal Aeronautical Soc., April, 1938, pages 291–346, 26 illus., 88 equations.

Aircraft

As Others Fly It. Diesel-powered fighters are under test abroad. Germany claims over 325 m.p.h. for a new Heinkel that has two cannons in the wings, two high-caliber machine guns and a 685-hp. Junkers Diesel. French have a Clerget Diesel in a Morane fighter. Brief ref. Aviation, April, 1938, page 61.

Contemporary Service Aeroplanes. Photographs only of the following: Belgian Fairey Battles; Fokker T.5 high-speed bomber (two 925-hp. Bristol Pegasuses, top speed 240 m.p.h.) built for the Netherlands Army Air Service; Henschel dive bombers of the German Luftwaffe; Caproni bombers and some fighters of the Italian Regia Aeronautica; Airspeed Queen Wasp target airplane; squadron of Junkers Ju.86 (600-hp. Junkers Jumo Diesels) heavy bombers of the German Luftwaffe; and Koolhoven F.K. 51 of the Netherlands East Indies Air Force. Comment is made that: "In Spain proof has been given that for interception of ordinary bombers and to fight off protective escorts, braced biplanes which will stand being pulled brusquely out of a dive still have their advantages. Hence the display here of German, Italian and Netherlandish biplanes. . . . In high-speed bombers . . monoplanes seem definitely to hold the fashion. The Junkers Ju.86 is the only one which has Diesel motors and slotted flaps so that it can land fairly slowly and will not burn up after a slight crash." Aeroplane, April 20, 1938, pages 474–475, 7 illus.

North Atlantic. Table of aircraft in construction or ready to be used over the North Atlantic covers characteristics for the following: Latécoère 631 20-passenger, S. E. 200 40-passenger, Cams 161 20-passenger, Latécoère 521 Lieutenant de Vaisseau Paris 30-passenger, Sikorsky S42B 32-passenger, Martin 156 416-passenger, Douglas D-C4 42-passenger, Boeing 314 50-passenger, Consolidated 54-passenger, D.H. Albatross D.H. 91 20-passenger, Short Empire Cambria 24-passenger, Short Mayo Composite 24-passenger, Armstrong-Whitworth Ensign 27-passenger, another Short plane, Hamburger Hal39, and the Junkers Ju 90 40-passenger aircraft. The Boeing 314, Latécoère 631, S.E.200, and Hal 39 are illustrated. Discussion covers a review of what has been done so far towards establishing an airline over the North Atlantic. L'Aerophile, March, 1938, pages 50–53, 9 illus., 1 table.

BELGIUM

Renard R.31 Two-Seater Observation Airplane and R.36 Single-Seater Pursuit. R.31 is a long-range high-wing airplane powered by a supercharged Rolls-Royce Kestrel developing 580 hp. at 2700 r.p.m. at 3500 meters. Top speed is 335 km./hr. at 4000 meters, range 1000 km. and time to climb to 4000 meters nine minutes.

A second article describes the Renard R.36 low-wing single-seater pursuit which can be transformed into a two seater combat airplane. It is powered by an Hispano-Suiza 12 Ycrs liquid-cooled motor-cannon giving 910 hp. at 3800 meters. Maximum speed is 505 km./hr. at 4000 meters and range 1000 km. Long description, characteristics, performance and armament are given for both airplanes. Rev. de l'Armée de l'Air, March, 1938, pages 331–335 and 335–339, 10 illus.

CZECHOSLOVAKIA

Practical Light Aeroplanes. Development of the Beřes and Mráz low-powered private airplanes, and details of the Bibi-Be 501 single-seater (Walter Mikron 45-hp. engine, 119 m.p.h.), Beta Minor Be-50 two-seater (Walter Minor 95-hp. engine, maximum speed 121 m.p.h.), Beta Minor Be 51 cabin-type (Walter Minor 95-hp. engine, maximum speed 130 m.p.h.), and Bibi-Be 550 two-seater (Walter Mikron II 60-hp. engine, maximum speed 121 m.p.h.). Aircraft Engineering, April, 1938, pages 105–106, 6 illus., 2 tables.

FRANCE

A.D.B.-60 Touring Airplane. Airplane powered with Salmson 60-hp. engine and having a maximum speed of 170 km./hr. at 1000 meters. Description. L'Aérophile, March, 1938, pages 64–65, 8 illus., 1 table.

Airplanes in Test. Brief references only to tests of the Potez 661 transport (four Renault 220-hp. engines) estimated to carry eight passengers at 250 km./hr. over 1000 km., and to the following military airplanes: Amiot 340 bomber (two Gnôme Rhône 14-No. engines); Marcel-Bloch 480 flying boat (two Gnôme Rhône 14-No. engines); Morane-Saulnier 405 C-1 No. 2; Bréguet 690 combat and light bomber (two Hispano Suiza 14-AB engines, estimated speed 500 km./hr.); and the Loire-Nieuport 161 pursuit.

Second issue—Breguet 730 military flying boat (four Gnôme Rhône 14 No. engines) has made its first flights. Estimated maximum speed is 320 km./hr., cruising speed 225–240 km./hr., time to climb to 3000 meters 9 min., and range more than 5000 km. Flying boat will carry eleven men and two boats, one of which has a motor. This prototype follows the same program as the Potez-Cams 141 and Latécoère 610. The latter will be equipped with four Gnôme Rhône L-18 engines and retractable floats under the engine nacelles. Brief reference. Les Ailes, March 31 and April 14, 1938, pages 8 and 9.

Air France's New European Fleet. The Bloch 220 16-passenger transport now in service on the London-Paris route (two Gnôme Rhône 14 890-hp. engines, range 620 miles at cruising speed of 180 m.p.h.). Some impressions and photographs. Flight, March 31, 1938, pages 316–317, 8 illus.

Airplanes in Test. Bréguet 690 three-seater fighter-command combat and light bomber (two Hispano-Suiza 14-AB engines) having a medium wing and tail surfaces with double fin. Few details of this airplane and references only to the following military aircraft in test: Morane-Saulnier 405 C-L single-seater pursuit (Hispano-Suiza 860-hp. motor cannon); Marcel-Bloch 170; Morane-Saulnier 350 single-seater acrobatic trainer; first Potez 630 bi-motored combat and light bomber (two Hispano-Suiza 14-AB); and the Marcel-Bloch 480 flying boat (two Gnôme Rhône 14-No. engines). Les Ailes, March 24, 1938, page 9.

Airplanes in Use or Designed for Private Aviation. Characteristics and performances for nine French light airplanes in use and for seven new types to be produced. Organization of private aviation in France is described in detail. L'Aérophile, February, 1938, pages 29–34, 32 illus., 2 tables.

An Altitude Flight of an Airplane Powered by the Clerget Heavy-Oil Engine. Flight to 7655 meters was recently made in 37 minutes by a Potez 25 airplane equipped with the Clerget 14-cylinder 500-hp. heavy-oil engine having double direct injection, compression-ignition and a Gnôme Rhône mechanical supercharger. Fuel consumption did not exceed 180 gr./hp.-hr. Technical characteristics of the engine, and a few results of the flight. L'Aérophile, February, 1938, page 45, 2 illus.

Bréguet G.10 Gyroplane. New gyroplane is intended for instruction and training, and military, mail and medical purposes. It is also intended as a transition design from the present experimental machine to the future gyroplane which, with a speed of more than 220 m.p.h., is to compete with the modern airplane. The G.10 is powered by a Hispano 9Q 350-hp. engine. It has the following performance with 4400 lb.: Rotor r.p.m. 148; speed 137 m.p.h. at 6560 ft.; ceiling for flight without forward speed 14,760 ft. and with forward speed 18,040 ft. Fuel consumption at 112 m.p.h. is 9.9 Imp. gal. per 62 miles. Desc. Interavia, April 26, 1938, pages 5–6, 1 illus.

A Flying Test Model. Flying scale model of the CAMS Potez 161, six-engined flying boat ordered by Air France for the North Atlantic, has been built with 60-hp.T rain engines. Work has actually been started on the 40 tonner. French military authorities are taking a great interest in heavy transport aircraft and are studying possibilities for these purposes of the Atlantic flying boats of Air France Transatlantique—the CAMS Potez 161, the Latécoère 631 and the Sud-Est 200. Brief reference. Flight, April 21, 1938, page 387.

Latécoère 298 Torpedo Seaplane. A. Frachet. All-metal torpedo seaplane is equipped with a Hispano-Suiza 12-Ycrs 880-hp. engine cannon and has a speed of 300 km./hr. at 2000 meters, a ceiling of 6000 meters, cruising speed of 270 km./hr. at 2000 meters, and range of 1500 km. Long description. Les Ailes, March 31, 1938, page 9, 2 illus., 1 table.

Lioré et Olivier H.246. Four-engined long-range 26-passenger commercial flying boat having metal hull and wooden wings. Four Hispano-Suiza Xirs 720-hp. ethylene-glycol-cooled engines power the flying boat. Maximum speed is 208 m.p.h. at 6560 ft. and range 930 miles. Long description. Aircraft Engineering, April, 1938, page 120, 3 illus., 1 table.

Mauboussin Prototypes. Mauboussin 200 trainer powered by a Regnier 90-hp. engine and having a maximum speed of 300 km./hr. Few details of this airplane as well as of the 123, 124, 160, and 190, also light airplanes. Les Ailes, April 14, 1938, page 7, 2 illus.

Potez 141 Flying Boat. Potez 141 naval flying boat (four Hispano-Suiza 12-Y 950-hp. engines) has a total weight of 22 to 24 tons, and top speed of 310 km./hr., carries 8 to 12 men, and flies for 25 to 30 hours. Construction, armament, characteristics, and performances. L'Aérophile, March, 1938, pages 60–61, 2 illus., 1 table.

Two-Seater Fighter—1880 Hp. First flights have been made with the Marcel Bloch 170 two-seater fighter (two Gnôme Rhône 14 No. radial engines giving a total of 1880 hp.). The fighter was intended for two Hispano-Suiza 14AA engines (2240 hp. total) but production difficulties have intervened. Wing area is 366 sq. ft. and all-up weight 13,200 lb. for the Gnôme-powered fighter. Introduction of this machine may mean that two-seater fighters with the small-diameter Gnôme-Rhônes or Hispanos of 700 hp. are not powerful enough to meet modern demands. Brief reference. Flight, April 14, 1938, page 368.

The Four Winds. The prototype Hanriot 220 twin-engined fighter, reported to have a maximum speed of 515 km./hr., recently crashed. Soon after taking off the starboard propeller and reduction gear broke away. Brief reference. Flight, April 7, 1938, page 339.

Paper Performance. It is estimated that the Amiot 340 bomber when powered by two Hispano 12Y engines of the new type giving 1200 hp. each will have a top speed of 348 m.p.h., ceiling of 32,800 ft., range of 1550 miles at 260 m.p.h., weight empty of 9900 lb., all-up weight of 19,800 lb. Similar performances are expected from the machine powered with a pair of Gnôme Rhône P-14s. Brief reference. Flight, March 31, 1938, page 324.

Paul Aubert "Cigale" Light Airplane. A. Frachet. Two-seater training and touring airplane constructed of wood and used for acrobatic work. With a 60-hp. Train engine it takes off in 125 meters and its cruising speed over 500 km. is 160 km./hr. Long description. Les Ailes, March 24, 1938, page 9, 4 illus., 2 tables.

Three Sport Airplanes in the Duralumin Competition. Allar 04 two-seater, Daspect 3 single-seater, and the Kellner-Béchereau EC-3 are airplanes of unusual designs which won the contest given by the Duralumin Company and which are now being produced. Description, characteristics, and performance. L'Aérophile, February, 1938, pages 35–36, 6 illus., 3 tables.

GERMANY

Blohm and Voss Single-Seater Pursuit Airplane. Blohm and Voss Ha-137-B monoplane (Junkers Jumo 210-C 40-hp.engine) may also be equipped for bombing and firing in a dive, trans orting 200 kg. of bombs. Armament

consists of two machine guns with synchronized fire installed in the fuselage and two machine guns or cannons fixed in the bend of the wing. Maximum speed is 340 km. /hr. and range 600 km. Short description and photographs showing instrument board, landing gear, engine mounting, and wing structure. L'Aérophile, February, 1938, page 27, 8 illus., 1 table.

A Diesel Triumph. Dornier Do. 18 flying boat (two 600-hp. Junkers Jumo heavy-oil engines) set up a World's record March 27–29. It was launched from the catapult ship Westfalen off Devon, England, and alighted at Caravellas, Brazil. Distance of 5242 miles was covered in 43 hours (122 m.p.h.). Account of flight. Aeroplane, April 6, 1938, page 409, 3 illus.

Short account of flight and cutaway drawing showing installation of engines. Fuel consumption was 155 gr. (0.341 lb.) per hp.-hr. Flight, April 7, 1938, page 349, 5 illus.

Dornier Do-19. Long-distance transport airplane (four Bramo 322 650-hp. radial aircooled engines) has a top speed of 320 km. /hr. Construction and characteristics. Luftwissen, February, 1938, pages 57–59, 1 illus.

Dornier Do-24 Combat Flying Boat. All-metal combat flying boat designed for operation on the high seas. Equipped with three 700/900-hp. aircooled engines, it has a maximum speed of 315/340 km. /hr. and range of more than 3500 km. Short description. L'Aérophile, February, 1938, page 26, 3 illus., 1 table.

Diesels and Flaps. "A Junkers Ju. 86 bomber (two 600-hp. Junkers Jumo 205 Diesel motors) of the German air force. The three gun-positions, should be noted. The full-span slotted flaps give quick take-off and slow landing." Brief reference. Aeroplane, April 13, 1938, page 443, 1 illus.

The Flying Pencil. H. F. King. Dornier Do. 17 bomber-fighter (two Daimler-Benz D.B.600 inverted vee-12 950-hp. engines), the Do.18 long-range reconnaissance and bombing-flying boat (two Junkers Jumo 205 560-hp. Diesels, top speed 160 m.p.h.), and the Do.24 flying boat built for the Netherlands government are described in an account of a visit to the Manzell plant of Dornier Metallbauten G.m.b.H. The Do.17 being built for Jugoslavia (two Gnôme Rhône 14 No. 14-cylinder two-row radial engines) is described in detail with a two-page cutaway drawing showing location of equipment and other drawings of the structure. Armament is discussed. The Jugoslav Do.17 flew from Friedrichshafen to Belgrade at an average speed of 268 m.p.h. Flight, April 14, 1938, pages 364a–364d, 365–366, 368, 12 illus.

Helicopter Progress. H. Focke. Reasons which caused the author to select the twin-rotor type for the Focke F. W.61 helicopter which has established new-world's records. Translation from Luftwissen, February. Flight, April 21, 1938, pages 380–383, 9 illus.

Parasol Prototype. One of the most stimulating single-seater fighter designs to be realized in recent times is the Focke-Wulf F.W. 159 parasol monoplane with inverted Junkers petrol engine . . . . the machine ought to be good for at least 270 m.p.h." Focke-Wulf has also introduced a new twin-engined general-purpose monoplane (Blenheim category) likewise powered with the inverted Junkers. Brief note. Flight, April 21, 1938, page 385.

The Focke Helicopter. H. Focke. Designer of the record-breaking helicopter discusses its emergency landing possibilities in case of failure of the driving mechanism, controllability and stability, general reliability, simplicity of operation by the pilot, and requisites of performance and maintenance. He describes the lift of the rotor, and the control and stabilizer, and compares the performance of autogiro and helicopter. Luftwissen, February, 1938, pages 33–39, 12 illus.

Focke-Wulf FW-200 Condor. Thirty-place transport powered by four B.M.W. Model 132G 720-hp. engines. Photograph only. Aero Digest, April, 1938, page 88, 1 illus.

Gotha Go-149. Go-149 may be used for training in aerobatics and combat, for transmission of orders, and for touring and sport and is equipped with camera gun and radio apparatus. Powered by an Argus As-10C 200 '240-hp. engine the airplane has a maximum speed of 345 km. /hr. and range of 950 km. at 320 km. /hr. cruising speed. Short description, characteristics, and performance. L'Aérophile, February, 1938, page 38, 2 illus., 1 table.

Junkers Ju-86K Fighters. Photograph of a group of Ju-86K fighters in flight, and another photograph of the Junkers Ju-87 dive-fighter. Luftwehr, February, 1938, pages 41, 65, 2 illus.

Junkers Ju-90 Transport. Forty-passenger 4-engined all-metal low-wing monoplane transport (four Junkers Jumo 211 1100-b.hp. engines) has a maximum speed of 256 m.p.h. Description. Aero Digest, April, 1938, page 58, 1 illus.

A Record Breaker. Heinkel float-seaplane (two 880-hp. B.M.W. 132 engines and V.D.M. fully-controllable propellers) set up eight new International Class Records on March 20. Records are for distances up to 1242 miles with payloads up to 4405 lb. at 204 m.p.h. Photograph only. Aeroplane, April 6, 1938, page 420, 1 illus.

Photograph only. Flight, March 31, 1938, page 326, 1 illus.

Brief note. Les Ailes, March 24, 1938, page 4.

GREAT BRITAIN

Hereford. Drawing of the Handley Page Hereford medium bomber, a type selected for production in the new Short and Harland factory at Belfast. Engines will be Napier Daggers of the newest type. Flight, March 31, 1938, page 324c, 1 illus.

Supermarine Spitfire Single-Seater Fighter. Fighter has been produced in large numbers for the British Metropolitan Air Force. It is equipped with a Rolls Royce Merlin 990 /1030-hp. engine and should exceed 500 km. 'hr. Brief reference. L'Aérophile, February, 1938, page 28.

DeHavilland D.H.95. New twin-engined all-metal high-wing transport monoplane under development (two Bristol Perseus XII engines) will carry 12 to 18 passengers and a crew of three. Disposable load will be about 5000 lb. cruising speed over 200 m.p.h. and rate of climb 1500 ft. /min. at sea level. Brief reference. Interavia, April 26, 1938, page 7.

New Fast Bomber. The Hereford bomber to be built at the Belfast factory of Short and Harland is a modified version of the Hampden and will be the second aircraft to be manufactured according to the Handley-Page system of rapid sectionalized construction. The Hampden has two Bristol radials while the Hereford has two Napier Dagger 24-cylinder H-shaped engines which on test have delivered as much as 50 hp. from each liter of cylinder capacity. Short note. U. S. Naval Inst. Proc., April, 1938, pages 619–620.

A Super Miles. Startling layout of the projected Miles X.2 transport having four buried engines with shaft drives. First layout studied is for 38 passengers and 700 gal. of gasoline, the second for 32 passengers and 1400 gal. of gasoline, and the third for 18 passengers and 2500 gal. of gasoline. Top speed at 11,000 ft. is estimated as 301 m.p.h., maximum cruising speed at that height 280 m.p.h., and maximum range at 61,128 lb. load about 4300 miles. A reduced-scale prototype is proposed for research. Description of the X.2 transport. Flight, April 21, 1938, pages 389, 378, 2 illus., 1 table.

HOLLAND

Koolhoven FK.54. Three-place touring and sport airplane powered with a DeHavilland Gipsy Major 130-hp. engine has a top speed of 250 km. /hr. and range of 1000 km. at 215 km. /hr. Description, characteristics, and performance. L'Aérophile, February, 1938, page 37, 2 illus., 1 table.

ITALY

Savoia Marchetti Airplanes. Savoia-Marchetti S-83 transport carries a crew of four and 10 passengers (three Alfa-Romeo 126 R.C.34 750-hp. engines) and has a top speed of 425 km. /hr. at 3400 meters. The S.75 transport (crew of four and 18 passengers) has a top speed of 363 km. /hr. at 4000 meters when powered with three Alfa-Romeo 126 R.C.34 engines, and 395 km. /hr. at 4500 meters when powered with three Piaggio XI R.C.40 1000-hp. engines. Construction, performance, and characteristics of both transports. Luftwissen, February, 1938, pages 58–59, 4 illus.

Savoia-Marchetti S-83 Trimotored Transport. Cantilever low-wing monoplane transport (three Alfa-Romeo 126 R.C.-34 680-hp. engines) is derived from the S-79. It carries a useful load of 3500 kg., and has a maximum speed of 425 km. /hr. and cruising speed of 380 km. /hr. at 5000 meters with 70 per cent power. Description, characteristics, performance. L'Aérophile, February, 1938, page 37, 1 illus.

Avanti Savoia. World's speed record for 1000 km. (621 miles) with a payload of 2000 kg. (4410 lb.) at 449 km. /hr. (278.5 m.p.h.) was recently recaptured by a Savoia Marchetti S.79 having three 1000-hp. Piaggio P.XI R.C.40 14-cylinder aircooled radials driving two-position controllable-pitch metal propellers. With the new engines maximum speed has been increased from 280 to 300 m.p.h. at 13,120 ft. Weight empty has gone up and normal disposable load has been reduced to 8180 lb. Presumably maximum overloaded weight remains the same at 29,790 lb. Brief note. Aeroplane, April 13, 1938, page 451.

Back to Italy. Eight of the seaplane records lost to Germany have been won back by M. Stofpani and G. Gorini flying a Cant Zappata 509 powered with three Fiat engines. Records are for distances of 1000 and 2000 km. with loads of 2000, 1000 and 500 kg. and without load. Speeds for the four laps were 241, 244, 249, and 252 m.p.h., respectively. Series production of the Cant Z.509 is now in progress and only Italian materials are used. Three 18-cylinder Fiat A.80 R.C.41 engines are fitted. Transoceanic services are in view. Brief note. Flight, April 21, 1938, page 383.

New Aeroplanes with Slots and Flaps. Savoia Marchetti S.79B four-seater high-speed long-range bomber (two Fiat A.80 RC.41 18-cylinder two-row radials giving 2060 hp. for take-off) has a top speed of 255 m.p.h. at 15,100 ft. and maximum range of 1800 miles. A bomb load of 2640 lb. can be carried a distance of 995 miles at 215 m.p.h. Armament consists of a fixed forward-firing machine gun for the front pilot, three other machine guns, and racks for 2760 lb. of bombs. Short description of armament and construction, with characteristics and performance.

Data are also given for the Savoia-Marchetti SM.75 28-passenger transport (three Alfa-Romeo 126 R.C.34 9-cylinder engines giving a total of 2340 hp. for take-off) which has a top speed of 228 m.p.h. at 12,160 ft. and range of 1435 miles. Construction, characteristics, and performance. Aeroplane, April 13, 1938, page 452, 4 illus., 2 tables.

U. S. A.

Boeing XB-15 Large Four-Engined Bomber. Few details including armament and comment that "maximum and cruising speeds remain very inferior to those of the YB-17 in spite of the retractable landing gear." A few details are also given for the XPB2Y-1 large bomber flying boat. L'Aérophile, March, 1938, pages 61–62, 1 illus.

Martin 156 Transatlantic Transport Flying Boat. Flying boat is powered by four Wright Cyclone 1820-G2 1000-hp. engines and has a maximum speed of 320 km. /hr., range of 5600 to 8000 km. and payload of 3400 kg. Description. L'Aérophile, March, 1938, page 63, 2 illus., 1 table.

Martin 166. Twin-engined bomber, an improved version of the 139W (B-10B), will be powered by two Wright Cyclones GR-1820-G3 each developing 840 hp. at 8700 ft. Top speed at critical altitude is 240 m.p.h. and maximum range at corresponding overload is 2000 miles at 160 m.p.h. Construction, armament, performance. Interavia, April 26, 1938, pages 9–10, 1 illus.

The Seversky Sev. 2 PA-LB (P-35). Two-seater high-speed fighter, light bomber, advanced trainer or observation airplane powered by one Wright Cyclone GR-1820-G3 giving 875 hp. for take-off. Top speed is 285 m.p.h. at 10,000 ft. Description, performance, characteristics. Aeroplane, April 13, 1938, pages 452A, 2 illus., 1 table.

Boeing "Stratoliner" Designed for Flight in the Substratosphere. Complete altitude conditioning apparatus for "upper level" flight at altitudes up to 20,000 ft. above sea level will be provided for the first two Boeing Model 307 33-passenger four-engined land transports. Other airplanes of the series will emerge from the production line identically designed and constructed but without the cabin supercharging equipment which will not be installed until the two initial supercharged planes have been tested. The sealed pressure cabin will increase the plane's normal soundproofing. Powered with four Wright GR-1820-G102 engines, the transport is expected to attain a maximum speed of 241 m.p.h. at 6000 ft. Very long description of the Stratoliners to be delivered to Pan American Airways and TWA. Estimated performances with these Wright engines are given and a graph shows effect of supercharging the cabin. Aero Digest, April, 1938, pages 20–23, 7 illus., 2 tables.

Shorter descriptions. Aviation, April, 1938, pages 38–39, 6 illus. U. S. Air Services, April, 1938, pages 16–18, 33, 2 illus.

Long description of the Boeing 307 and 307S, and diagram showing how air is drawn in through the leading edge of the wing, compressed by the superchargers, warmed, and circulated. Flight, April 7, 1938, pages 343–344, 3 illus.

Curtiss P-37 Pursuit. Army Air Corps P-37 pursuit has a top speed well over 300 m.p.h. and is equipped with a liquid-cooled engine. Few details and photograph of the P-36. Scientific Am., May, 1938, page 289, 1 illus.

Finds More Worlds to Conquer. Lockheed Aircraft Corporation's plans to enter the world's miiitary aircraft market. Brief reference to the Army Air Corps XC-35 stratosphere airplane, to a personnel transport version of the Model 12 submitted in a current Air Corps competition, to a modified Model 14 cargo airplane currently under consideration by the Air Corps, and to a new tactical-type Lockheed designed to meet Army Air Corps needs and thought to be a bomber version of the Model 14. Short note. Aviation, April, 1938, page 59, 1 illus.

Seversky Talks Big. A bomber version of the Seversky Super Clipper flying boat proposed for Pan American Airways should carry ten 2000-lb. bombs and have a range of 12,000 miles, and as a military machine it could carry a sizable torpedo motor boat to be used for stopping and searching ships. Description of the Super Clipper 120-passenger flying boat (eight liquid-cooled engines each giving 2300 hp. for take-off) submitted to Pan American Airways. Cruising range is estimated as over 5000 miles at 250 m.p.h. and maximum speed as over 300 m.p.h. The flying boat would have two fuselages and central nacelle with engines would be arranged in them as well as in the wings for driving tractor and pusher propellers. Aeroplane, April 6, 1938, pages 425, 407, 1 illus., Flight, March 31, 1938, page 325, 1 illus.

Brief description. U. S. Air Services, April, 1938, page 36.

Photographs only. Aviation, April, 1938, page 52, 1 illus. Aero Digest, April, 1938, page 45, 1 illus.

U. S. S. R.

Short Notes. It is reported that the Russian designer Bogdanow is developing a two-seater multi-purpose airplane, Type B-1, having a total weight loaded of 2400 kg., and M-34 840-hp. engine, and a top speed of 420 km./hr. Brief reference. Luftwehr, February, 1938, page 82.

Ryan Two-Seater Military Trainer. Few details, characteristics, and performance of the Ryan SC military trainer (Menasco 150-hp. engine; top speed 244 km./hr.). L'Aérophile, February, 1938, page 26, 1 illus.

Timm 840. Tricycle landing gear, hydraulic brakes on all three wheels, self-energizing hydraulic system for steering the nose wheel, and Handley-Page system of slots, slotted flaps, and slotted ailerons are provided on the six-place twin-engined transport designed for operators of small airlines. The airplane has cargo capacity for 180 lb. of baggage and 200 lb. of mail. Powered by two Wright Whirlwinds R975E-3 developing 420 hp. at 2200 r.p.m. at 1400 ft. it has a maximum speed of 207 m.p.h. at critical altitude and range of 705 miles at 75 per cent power. Long description. Aviation, April, 1938, pages 40–41, 72, 5 illus.

Short description. Western Flying, March, 1938, page 21, 1 illus.

Trimmer Seaplane. New light seaplane is powered by a 50-hp. Salmson radial and has an estimated top speed of 85 m.p.h. Few details. Aviation, April, 1938, page 48, 2 illus.

Aircraft Accidents

As Others Fly It. Stoppani crash off the Brazilian coast is now said to be due to fire breaking out at 10,000 ft. following a backfire. The plane was landed without injury but exploded in the water. Brief reference to this accident and to that to the Junkers Ju 90 during artificial vibration tests. Aviation, April, 1938, page 61.

Stratosphere Aeroplane Crash. Belgian low-wing all-metal monoplane, specially built for flying in the stratosphere, crashed on its first flight. Airplane weighed about 10 tons and was capable of carrying 20 passengers and a crew of three at a height of nearly 20,000 ft. Brief reference. Engineer, April 8, 1938, page 393.

Propellers

Aerodynamic Considerations Affecting Propellers for Large Aircraft Engines. G. W. Brady. From the aerodynamic standpoint, propellers of the type considered having blades of fixed diameter and of fixed pitch distribution, but rotatable about their axis in a controllable hub, can be designed to operate efficiently for engines of any powers. Effects of variations in propeller diameter, number of blades, and engine gear ratio on take-off and on high-speed and cruising flight are discussed in detail. Blade width and planform, pitch distribution, shank fairing, propeller torque, feathering, and propeller clearance with large diameters are also considered. S.A.E., Preprint for Meeting, March 10–11, 1938, 30 pages, 20 illus., 10 equations.

Approved Airscrew Protection. Rayoid, a new method of treating propellers, has passed Air Ministry tests at Farnborough. Brief reference only. Flight, April 7, 1938, page 338.

As Others Fly It. A 120° pitch change propeller made by Ratier has been tested on the four-engined French flying boat CAMS 141. For maneuvering on the water, outboard propellers are set for thrust astern and inboard propellers for thrust ahead. By working the throttles the boat can be sent in either direction or spun around short. Engines are warmed up at zero pitch. Brief reference. Aviation, April, 1938, page 60.

Aerodynamics of the Airscrew. "Practical Airscrew Performance Calculations," by F. M. Thomas, F. W. Caldwell, and T. B. Rhines. This paper was presented before the Royal Aeronautical Society and was the cause of a controversy at the meeting. Spoken lecture is given here with essential charts required to carry out the method. Some additional information is added. Aircraft Engineering, April, 1938, pages 109–119, 30 illus.

Thrust and Moments of the Propeller in the Case of Oblique Airflow and Turning of the Airplane. G. Klingemann and F. Weinig. Method of calculating propeller thrust and moments for elements of a multibladed propeller in straight and curved flight paths, as well as for the entire propeller. Division of the ring elements, average value of the axial and rotary forces, and transverse thrust and moment are expressed for the propeller elements in both straight and curved flight paths. Equations are developed for the effect of oblique airflow for the straight path, and for the influence of a change of angle of incidence and sliding angle for the case of the curved flight path. Formulas are also derived for the relations between propeller elements and entire propeller, and for coefficients of the entire propeller in case of oblique airflow and in the case of a curved flight path. DVL report Luftfahrtforschung, April 6, 1938, pages 206–213, 7 illus., many equations.

Gaba Propeller with Pitch Controllable in Flight and Reversible for Landing. Lt. Col. A. Gaba. For controlling the pitch of the Gaba G.41 propeller the pilot has an automatic control in flight (low speed) with autoregulation of the engine, a hand control in flight (low speed) to supplement the automatic control, and a hand control (high speed) for inversion of the pitch for landing and for maneuvers on the ground. For take-off and flight the clutches of the pitch control are actuated automatically by an electro-distributor with oil actuated by the contractor-tachometer. The contactor carries an index by means of which the pilot marks the speed desired for the engine. Long description and many drawings of the G.41 propeller for high-powered engines, and details of the G.40 for 250-hp. engines. L'Aéronautique, February, 1938, pages 22–27, 10 illus.

Propeller Factors Tending to Limit Aircraft Engine Powers. G. T. Lampton. "If present trends persist, propellers previously considered in the Zeppelin category will shortly be standard equipment on pursuit ships." Effect on propeller design of increasing airplane speeds to 450 m.p.h. resulting in increased pitches and eventually a loss of efficiency is considered. The discussion covers: limitations of critical speed of the propeller, propeller efficiency, increased propeller weight, diameters required for 3, 4 and 6-bladed propellers for 250 and 450 m.p.h., increased propeller weight largely offset by reduction of engine weight, and specific thrust horsepowers. S.A.E., Preprint for Meeting, March 10–11, 1938, 12 pages, 10 illus.

Propeller Problems Imposed by Substratosphere Flight Requirements. C. F. Baker. Counter-rotating propellers should definitely be considered for the single-engined airplane particularly where torque is a problem. Problems in the design of propellers for high-altitude flight are discussed including: methods of increasing total blade area, and the increased weight involved; weight variation with power requirements and results of a study determining diameters for each of three propeller types; possibilities of reducing weights; and comparison of a four-blade counter-rotating tandem propeller with three-blade and four-blade single rotating propellers. S.A.E., Preprint for Meeting, March 10–11, 1938, 11 pages, 6 illus., 3 tables.

Stratospheric Flight from Viewpoint of the Propeller Designer. Bradley Jones. Discussion of paper by C. F. Baker on propeller design for stratospheric flight and comments on the papers entitled "Carburetor Icing," R. Sanders and "Ground Training for Instrument Flying," Capt. C. J. Crane. These papers were presented at the Washington meeting of the S.A.E. U.S. Air Services, April, 1938, pages 23, 36.

Rocket Propulsion

Number One Rocket Man. G. E. Pendray. Work of R. H. Goddard in the development of liquid-fuel rockets, his test station in New Mexico, and his development of a gyroscopically-operated control mechanism. Scientific Am., May, 1938, pages 270–272, 3 illus.

Aircraft Instruments and Navigation

Flying the Comet. Flying Officer A. E. Clouston. Navigational and flying technique employed by the author in his recent England-New Zealand flight which covered a distance of 26,500 miles in less than eleven days. Method of landing and taking off with the Comet as well as navigation methods are described. Drawing of the cockpit shows location of instruments for the flight. Flight, April 7, 1938, pages 336–338, 4 illus.

Short account of return journey. Flight, March 31, 1938, page 318, 2 illus. Aeroplane, March 30, 1938, pages 379–380, 2 illus.

Layer Cake Blind Flying. New British device is reported to use a cathode-ray tube to indicate the airplane's position on a map in the cockpit, and to operate by automatically taking bearings on two radio stations. Brief reference to this device and to Air Ministry regulations dividing the air from 3300 to 18,600 ft. into zones each subdivided into 12 layers, one for every 30° of compass courses. Aviation, April, 1938, page 61.

Miscellaneous Equipment

The Deutsche Lufthansa Seaplane Catapult Motorship "Friesenland." Heinkel catapult; method of maneuvering seaplanes about the deck; pumping system for dealing with fuel for the seaplanes; and internal-combustion propelling machinery of the ship. Concluded. Engineering, April 15, 1938, pages 414–415, 6 illus.

The Catapult Toboggan. L. Petit. Possibility of facilitating the take-off of heavily-loaded airplanes for transatlantic service by launching them on an inclined plane. Discussion and drawing of the project proposed. Les Ailes, March 24, 1938, page 8, 1 illus.

Williams and His Oxygen Equipment. Oxygen equipment used by J. Williams in his recent parachute jump in France from an altitude of 11,265 meters. Equipment operated perfectly under a temperature deviation of 70° and a pressure variation of 580 mm. of mercury in 170 seconds, and weighed only 1,650 gr. Short description. Les Ailes, April 14, 1938, page 8, 2 illus.

Bases for Seaplanes. D. D. Cooke. Development of seaplane landing and storage bases, handling equipment, suggestions for future designs, private storage bases, and efficiency of marine railways. Aero Digest, April, 1938, pages 24–28, 15 illus.

Horizontal Beam Runway Marker. New Westinghouse runway marker casts a horizontal beam 90 per cent of which is held within 10° of the horizontal. Unit has a sodium-vapor lamp. All parts but the elongated button head are buried beneath the ground and the lens is made of Herculite glass which can withstand the full weight of a transport airplane. Brief note. Aero Digest, April, 1938, page 62.

Engine Design and Research

Exhaust Systems of Two-Stroke Engines. H. O. Farmer. Normal type of crankcase-scavenge two-stroke engine was tested in which inlet and exhaust ports in the cylinder wall were controlled by the working piston. Comparatively short lengths of plain pipe connected directly to the cylinder, and combinations of pipes and an expansion box were tested. A self-induction engine also discussed makes use of pressure variations in the exhaust pipe to scavenge the cylinder and to pump in the fresh air charge without use of an auxiliary air pump. Discussion of the paper made by Wing Commander Cave-Browne-Cave and others is included in a second article. British Institution of Mechanical Engineers paper. Engineering, April 1, 1938, pages 367–369 and 362–363, 10 illus., 2 tables.

Progress of the Diesel Engine. H. Ricardo. Superiority of the Diesel over the gasoline engine should be obtained by a large number of small cylinders operating very rapidly. Diesel problems in regard to the four-cycle engine with high compression and low supercharging, the two-cycle with high compression, and the four-cycle with low compression and high supercharging are considered. Les Ailes, March 24, 1938, page 7, 1 illus.

The Diesel as a High-Output Engine for Aircraft. E. G. Whitney and H. H. Foster. Four-stroke-cycle Diesel with present technique of combustion control, through use of higher boost pressures and with maximum cylinder pressure not over 1400 lb./sq. in., can provide a maximum power for take-off equal to that obtainable from present gasoline engines using 100-octane fuel. The same Diesel can obtain lower specific fuel consumptions than the lowest obtainable from the gasoline engine using 100-octane fuel.

From NACA single-cylinder tests, power and fuel-consumption curves have been calculated for a highly-boosted multicylinder Diesel engine. Influence of inlet-air temperature and maximum cylinder pressure on attainable mean effective pressure for a given specific fuel consumption is demonstrated. Theoretical Diesel-cycle performance curves are included to show gains possible by further improvement and control of combustion rates. Performance to be expected from the two-stroke-cycle Diesel is estimated. Discussion by R. Insley and E. S. Hall included. S.A.E. Jour. (Trans.), April, 1938, pages 161–169, 14 illus.

Recent Developments in High-Speed Oil Engines. S. J. Davies. Practical limitations of ignition lag. Internal and external factors determining ignition lag; chemical and physical changes; influence of air-fuel ratio; methods of measuring ignition lag and correlating its value under certain specified conditions with cetane number; measurement of rapidly fluctuating quantities such as pressures, and resulting mechanical movements; measurement of strains in moving and stationary parts of engines, studied by Le Mesurier and Stansfield; and proposals to utilize energy in escaping gases in order to bring about the recharging of the cylinder. Concluded. Institution of Mechanical Engineers paper. Engineering, April 8, 1938, pages 400–404, 7 illus.

Some Problems in the Development of Aircraft Engines. M. Christian. Possibilities of obtaining higher performance by means of larger cylinder capacity and higher power for the cylinder capacity, less weight, reduction of form drag, introduction of air cooling, and reduction of fuel consumption, as well as special requirements of operation at higher altitudes and the accompanying regulation question. German and foreign engines and parts are referred to and illustrated. A.T.Z. March 25, 1938, pages 153–160, 29 illus.

Torsional Vibration of In-Line Aircraft Engines. R. M. Hazen and O. V. Montieth. Natural vibration frequencies; three designs of crankshaft torsional equivalent systems and the type being used on the standard Allison V-1710 engine; harmonic torque input; selection of vibration frequencies; method used to make an analysis of the frequency characteristics of an engine; torsional vibration dampers; two types of friction dampers, one being used on the standard Allison V-1710 engine; engine damping; and interpretation of torsiometer data. S.A.E., Preprint for Meeting, March 10–11, 1938, 21 pages, 11 illus.

A Novel French Project. Six two-cylinder power units are arranged around the coaxial propeller shafts in the Gadoux design for a 900-hp. 12-cylinder supercharged engine. Engine is liquid-cooled and intended for a small high-efficiency fighter with a shell gun firing through the propeller shafts. Torque reaction is automatically cancelled out by use of concentric propellers rotating in opposite directions. Translation from Les Ailes. Flight, April 21, 1938, page 388a, 1 illus.

The Standard Shadow Factory. Specialized methods employed in the production of Bristol Mercury cylinder units consisting of cylinder barrel and head, and subsidiary parts such as cylinder head ring, copper gasket, valve guides, valve seats, spark-plug adaptors, inlet elbows, and cylinder lugs. Drawings show details of the cylinder head and vertical fins, and the complete cylinder assembly. Long description. Automobile Engineering, April, 1938, pages 123–130, 22 illus.

Operating Characteristics of Engines. P. de Valroger. Selection of the principal parameters for the nominal regime on the ground and at altitude, and at overload, overspeed and additional torque is considered. Tests of the engine alone and mounted on the aircraft are discussed. Conclusion of article explaining terms and regulations of the Service Technique for testing aircraft engines. L'Aéronautique, L'Aérotechnique Supplement, February, 1938, pages 18–24, 4 illus.

Engines

The Coatalen Diesel. Twelve-cylinder French aircraft engine with conconstant-pressure injection system and a total swept capacity of 36,050 c.c. The twelve cylinders of 150-mm. bore and 170-mm. stroke are arranged in two water-cooled banks of six at a 60-degree angle. At normal maximum speed of 2000 r.p.m. at the crankshaft 550 b.hp. is developed. Mounted on the cylinder axis, the fuel-injection valve has 10 jets of 0.13-mm. diameter by which fuel is sprayed radially at a pressure of 10,000 lb. /sq. in. into the open combustion chamber. Long detailed description. Automobile Engineering, March, 1938, pages 77–81, 11 illus.

Double Row Cyclone. Wright Double-Row Cyclone 14. 14-cylinder engine, four of which will power the Boeing Clipper 314 transoceanic flying boats. Engine has passed Bureau of Air Commerce and Air Corps tests, at a take-off rating of 1500 hp. and rating of 1200 hp. for normal sea-level operation. Total cylinder displacement is 2600 cu. in. Few details. Aviation, April, 1938, page 47, 3 illus. U.S. Air Services, April, 1938, page 30, 1 illus.

Franklin Aircooled Fifty Horsepower Engine. Four-cylinder horizontally-opposed aircraft engine has a displacement of 150 cu. in. and a compression ratio of 6.6:1 and develops 50 hp. at 2300 r.p.m. It has been designed by former engineers of the Franklin Automobile Company. Very long desc. Aero Digest, April, 1938, pages 32, 92, 3 illus. Automotive Industries, April 9, 1938, pages 518–520, 3 illus.

Germany's Big Nine. Bramo Fafnir 323 radial engine appears in fully and moderately supercharged forms, supercharger impeller speeds being 11.4 and 9.5:1, respectively. Moderately supercharged version develops 950 hp. at 2450 r.p.m. for take-off, 840 hp. at 2350 r.p.m. at 6730 ft. rated, and 670 hp. at 2100 r.p.m. at 6730 ft. for cruising. Fully supercharged version gives 850 hp. at 2450 r.p.m. for take-off, 830 hp. at 2350 r.p.m. at 13,750 ft. rated and 665 hp. at 2100 r.p.m. at 13,750 ft. for cruising. Short description. A few details and photographs of the Wright Cyclone 14, engine giving 1500 hp. for take-off are included. Flight, March 31, 1938, page 326, 3 illus.

International Aircraft Show at Milan. Engines exhibited at the Show are discussed, with illustrations of the following: Fiat A.74 R.C. 14-cylinder, Alfa Romeo 135 R.C. 18-cylinder, and Fiat A.80 R.C. 18-cylinder, and Fiat A-80 R.C. 18-cylinder double-row aircooled radials; Bramo 323 Fafnir 9-cylinder radial; Isotta-Fraschini Asso L.121 R.C. 12-cylinder two-row inline liquid-cooled; Junkers Jumo 210 12-cylinder two-row liquid-cooled; Isotta Fraschini Asso XI R.2.C. 12-cylinder vee water-cooled; and Hirth HM 508 H 8-cylinder two-row inline engines. The text refers to the following new engines: a Piaggio P XII R.C. 40 18-cylinder two-row radial (not less than 1600 hp.); the Alfa Romeo 135 R.C. 32 18-cylinder two-row radial (1500 hp.); the Fiat A.80 R.C.20 18-cylinder (1100/1200 hp.); the Hispano-Suiza 14 AA (1000 hp.) and 14 AB (670 hp.); and Gnôme Rhône 18P (1500 hp.) and 14M (650-hp.). General trends in engine development are discussed. Luftwissen, February, 1938, pages 53–56, 8 illus.

Alvis Arrival. Already completed and on test, the new medium supercharged 9-cylinder Alvis radial measures only 41.5 in. in diameter. Capacity is 11.78 liters and normal output is 375 hp. at 3000 r.p.m. at 5000 ft. Photograph only. Flight, April 21, 1938, page 383, 2 illus.

The Aspin Engine. Revised edition of the Aspin rotary-combustion-chamber engine is nearing completion. The flat four arrangement is preserved but a three-throw crankshaft will replace the original two-throw shaft to eliminate a couple apparent when the unit was flexibly mounted. Two magnetos are set transversely at the rear. Brief note. Flight, April 21, 1938, page 394.

Over 900 Hp. from the Perseus. Perseus XII moderately supercharged nine-cylinder sleeve-valve radial engine of 52-in. diameter develops 905 hp. at 6000 ft. Take-off output is 795/830 hp. and international rating 715/745 hp. at 6500 ft. Latest type of Claudel-Hobson fully-automatic carburetor is specified. Improvements in design are described. Flight, April 14, 1938, pages 372–373, 4 illus. Aeroplane, April 13, 1938, page 453, 2 illus. Engineer, April 22, 1938, page 455, 2 illus.

Technical Notes. M. Botali has built a two-cycle 4-cylinder radial of 30.5-liter capacity which develops 100 hp. at 1850 r.p.m. Scavenging pumps are placed in radial arrangement also between the cylinders. First results are promising. Brief reference. Les Ailes, March 31, 1938, page 8.

Towards the Steam-Driven Aeroplane. Aero Turbines has been formed in England to develop a combined rotary boiler and steam turbine which they believe has great possibilities as a power unit for aircraft. To start the engine, the boiler and a rotary pump built into it are turned around by the starter motor. Water drawn from the condenser sump is forced into an annular distribution chamber, through nozzles which atomize it and into the inlet leg of U-shaped tubes. Combustible mixture of air and oil has been passed into an annular distribution chamber and ignited electrically, the resultant flames playing on the U-tubes. Short description and drawing. Aeroplane, April 13, 1938, page 452A, 1 illus. Flight, April 14, 1938, page 374, 1 illus.

Jacobs 300-Hp. Model L-6 Engine. Model L-6 seven-cylinder engine is rated at 300 hp. at 2100 r.p.m. at 3700 ft., 330-hp. at 2200 r.p.m. for take-off, and 220 hp. at 12,000 ft. The three models, L-6, L-6M, and L-6MB are basically identical but have different types of ignition systems. Long description. Aero Digest, April, 1938, pages 60, 92, 2 illus., 1 table.

Latest Twelve-Cylinder Ranger Engines. W. J. Carry. New ratings include a 450-hp. take-off rating for the 3:2 geared and 8.84:1 supercharged SGV-770B5 engine. Normal horsepower is 420 at 2800 r.p.m., and recommended cruising limits are 300 to 315 hp. to 9000 ft. at 2400 and 2500 r.p.m., respectively. Take-off rating for the direct-drive V-770B-4 model is 315 hp. at 2400 r.p.m., normal horsepower 305 at 2300 r.p.m., and recommended cruising limit 230 hp. at 2150 r.p.m. Long descriptions of the engines pointing out improvements in the design. Aero Digest, April, 1938, pages 46, 48, 90, 7 illus., 1 table.

Milwaukee Sky Motor. Model 70 four-cylinder inverted inline engine develops a maximum of 70 hp. at 2350 r.p.m. Short description. Aviation, April, 1938, page 48, 1 table.

Technical Notes. P. Clerget and R. Marchal. High-altitude operation of the Clerget heavy-oil engine having double injection and a 14.5 to 1 compression ratio, and developing 500 hp. at 1900 r.p.m. at 2700 meters. A Gnôme Rhône supercharger with mechanical control was used. Combustion is optimum at 6000 meters where a weight ratio of air to fuel is 14. Short abstract of Academi des Sciences paper. Les Ailes, March 24, 1938, page 8.

Parts and Accessories

Cooling the Gipsy Twelve. New DeHavilland pressure-duct system used on the four-engined Albatross. Gipsy Twelve inverted-vee geared and supercharged engine is cooled by air supplied at controlled pressure from ducts in the leading edge of the wing. Details, development of the system, drawing and photograph of the installation. Flight, March 31, 1938, page 331, 3 illus. Aeroplane, March 30, 1938, page 391, 3 illus.

Metals

Real "Pop" Riveting. Heinkel process of explosion riveting of sheets onto closed tubes in which it is difficult to get at the rivet shank for forming the head. A hole is driven in the shank and filled with a special explosive which expands the shank, forming a head. It is said to be watertight. Short description. Flight, Aircraft Engr. Sup., March 31, 1938, page 20, 2 illus.

Beryllium-Aluminum Alloys for Aircraft Pistons. J. B. Johnson. Tensile strength at 500° F. and Brinell hardness after heating are approximately equal to those for the forged 14-per cent silicon-aluminum alloy extensively used for aircraft pistons. Conductivity is approximately one-half, which would cause the beryllium-aluminum pistons to operate at a higher temperature. Microstructure is a network of hard eutectic and softer matrix. Chemical composition, and mechanical properties at room temperature and at 500° F. are given. Metals & Alloys, April, 1938, page 94, 3 illus., 2 tables.

Applications of Wrought Elektron in the Aircraft Industry. D. B. Winter. One of the big advantages of Elektron over aluminum alloy is its weldability. Welding, riveting and working Elektron sheet; fabrication of Elektron fuel tanks; curves comparing relative weights of fuel tanks in brass, aluminum, steel and Elektron; construction of Elektron seats; and Elektron sheets used as surface covering. Aeroplane, April 20, 1938, pages 476–478, 6 illus.

Radio

Aero Radio Digest. Bendix Type TG-6A 1000-watt 10-frequency aeronautical ground transmitter; RCA television long-range aircraft detector; new ultra-high-frequency four-course radio-range beacon developed by the Bureau of Air Commerce and installed at Indianapolis; Simon Radioguide Model F radio direction finder developed especially for airline requirements; RCA Model AVA-14A safety release for aircraft trailing antenna; Communications Model B lightweight dry-cell-operated radio-range receiver; and a 125-mcs. traffic-control installation being tested by the Bureau of Air Commerce at Indianapolis Airport. Short descriptions. Aero Digest, April, 1938, pages 70, 72, 7 illus.

Aircraft Radio. Simon Radioguide double-loop direction finder employing two-channel receiver; Collins Model 17D high-power transmitter designed for use on airliners and using the Autotune system; Heinemann Re-Cirk-It breakers and special housing; Aerovoice R40 (remote-controlled) and D40 (direct-controlled) high-power transmitters; Standard Transformer Stancor 10-Aero 3-watt 16-lb. two-tube transmitter for contact with airport traffic control towers. Short descriptions. Aviation, April, 1938, pages 63, 72, 3 illus.

Rotary Radio Beacons. E. Kramer and H. W. Roberts. Basic principles and method of operation of the rotary radio ranges. The type discussed in detail is represented by a uniformly rotating beam accompanied by an identifying signal when it points in a definite direction. Principles of operation of rotating null-line, of rotating positive-signal beam, and of the rotating pear-shaped directional beam, a rotary radio beacon employing a null-line beam, and a rotary radio beacon employing a positive-signal range beam are discussed and illustrated. An electromechanical signal counter which converts received signals into a visual bearing indication is described. Aero Digest, April, 1938, pages 38, 40, 6 illus.

Reduction of Night Error by Means of the Adcock Receiving Antenna. H. Busignies. Causes of night error and night error in a loop antenna are explained. The Adcock receiving antenna is considered in regard to: principle of reduction of night error and error of the airplane; radiation characteristics of a loop antenna; system of vertical antennas; and technique of the

Adcock receiving antenna. The RC6 and RC6A direction finders are described including: direction-finder circuit; transformer and lines; compensation; suppression of the ambiguity of 180°; receiver; supply; sensitivity; and background noise. To be continued. L'Onde Électrique, March, 1938, pages 105–127, 9 illus.

Practical Aircraft Navigation and Communication. W. P. Lear. Requirements for a successful radio compass. Very brief abstract of a Montreal Section paper. Brief abstract is also given of paper by M. O'Day entitled "Snow Static" which was presented before the Seattle Section. Inst. Radio Engrs., Proc., April, 1938, pages 395 and 397–398.

The "ZZ" Method of Blind Approach. Lord Malcolm Douglas-Hamilton. "The ideal is to have facilities for Lorenz as well as ZZ blind approaches and an aircraft and crew equipped in skill and apparatus to use either or both simultaneously . . . . The German Luftwaffe train all their pilots in the procedure of ZZ blind approaches . . . The Hegenberger is easier than the ZZ system . . . and the Lorenz is considerably easier, but there are conditions where the Hegenberger and Lorenz methods could not be used and practical use could be made of the ZZ method." Description of the ZZ method and comparison with the Lorenz system. Aeroplane, April 20, 1938, page 480–482, 2 illus.

Photography

Aerial Mapping. New stereo-mapping projector has just come from Bausch and Lomb Optical Company and will be used by the U.S. Army Air Corps for military work. Short description. Jour. Applied Physics, April, 1938, pages 271–272.

Testing Apparatus

Vibration Frequency Meter. Sheffield vibration-frequency meter has been developed to determine vibration resonances of wings, fuselage and other aircraft members. It may also be used as a tensiometer to determine loading of wires and rods. Short description. Aero Digest, April, 1938, pages 62, 64, 1 illus. Aviation, April, 1938, pages 66–67, 1 illus.

Scratch Apparatus for Recording Rapidly Changing Stresses, Pressures and Forces. A. Freise. External forces and pressures acting on parts of structures and the stresses produced by them are easily determined by the elastic deformations. In the scratch process of the DVL the mechanical deformation is scratched by means of a diamond in natural size on hard recording surfaces and evaluated under a microscope or by microphotograph. V.D.I., April 16, 1938, pages 457–461, 17 illus.

Acoustics

New Technique for Noise Reduction. E. J. Abbott. Paper and discussion by S. J. Zand, W. A. Wagstaff, J. S. Parkinson and P. Loomis. S.A.E. Jour. (Trans.), April, 1938, pages 170–184, 13 illus., 4 tables.

Meteorology

Royal Meterological Society. "Atlantic Flight and its Bearings on Meterology," F. Entwistle. Preliminary investigation and results of the North Atlantic flights made by Imperial Airways and Pan American flying boats. Abstract of paper. Engineering, April 1, 1938, pages 369–370. Short abstract. Flight, March 31, 1938, page 328.

Thunderstorm Forecasting with the Aid of Isentropic Charts. J. Namias. Use of tephigrams and sources of error are described and it is shown that the assumption that any one particle of air rises adiabatically and otherwise undisturbed through a resting medium is incorrect, and that airplane soundings taken in early morning are not representative of upper-air conditions throughout the rest of the day. There are advectional and thermodynamic changes taking place in the overlying atmosphere after soundings are made, which appreciably alter their characteristics. The author shows these conclusions are correct, and that the isentropic chart offers a promising means of taking both factors into account. Am. Meterological Soc., Bul., January, 1938, pages 1–14, 9 illus.

Abstracts, Indianapolis Meeting. "A Precision Radiometeorograph," L. F. Curtiss and A. V. Astin. "Air Mass Climate of Central Pennsylvania," H. Landsberg. "Advances in International Meterology in 1936 and 1937," W. R. Gregg. "Geographical Correlations in the United States," L. F. Page. "The Discovery of a New Constituent of the Earth's Upper Atmosphere, Nitrogen Pentoxide," A. Adel and C. O. Lampland. "A Periodogram Investigation of Short-Period Sunspot Cycles," D. Alter. Short abstracts. Am. Meterological Soc., Bul., January, 1938, pages 29–34.

Aeronautical Industry and Production

Canada/Mexico/Great Britain: Aircraft Construction. Canadian Car and Foundry Company intends to take up the manufacture of aircraft in the military arsenal of Mexico City. Brief note. Interavia, April 26, 1938, pages 6–7.

Shadow Factory Costs. Report of Comptroller and Auditor-General on the Air Services Appropriation Account for the year ending March 1937. Quotations regarding net cost of the Shadow Industry. Interavia, April 26, 1938, pages 7–8.

Bendix Sets Up Coast Unit. Bendix Instrument Company has been established in Los Angeles. In addition to handling sales and service on Pioneer and Bendix products the new firm will develop and market a number of new instrument and accessories, among them a cable tension-measuring instrument and a propeller blade pitch indicator for quickly determining pitch in the field. Brief note. Aviation, April, 1938, page 54.

Britain's Shadow Plants. Organization and development of the shadow plan to erect 14 factories (nine aircraft factories) to provide a reserve capacity for production in time of war. Range of each aircraft factory will be widened until each component part is made in at least three factories. Editorial. Am. Machinist, April 6, 1938, pages 290, 290a–290d, 3 illus.

Foreign News in Brief. Establishment of an aircraft factory at Mukden is being planned by Japanese authorities. Brief reference. Aero Digest, April, 1938, page 88.

Martin's New Assembly Plant. Assembly building measuring 300 x 450 ft. is spacious enough to allow assembly of planes larger than any yet built. Twelve planes of the Russian Clipper (wing span 165 ft.) could be assembled in the building at one time. Height from floor to roof truss is 43 ft. 6 in. Description of plant. Aero Digest, April, 1938, page 36, 2 illus.

Air Warfare

Air Warfare in Spain Viewed from the Loyalist Side. C. Sweeny. Notes taken during a visit with General Armengaud during November and December, 1937. Personnel and training, aircraft, the Loyalist pilots' estimate of the enemy's airplanes, factories, and general tactics are discussed. Comments are made on the "Natacha" (Bréguet 19) used for night bombing, "Katchouska" bomber (modified Trait-d'Union type), "Mosca" and "Chato" (Boeing) pursuits, a Fokker biplane on the Loyalist side, and to the Messerschmidt and other airplanes used by the Nationalists. L'Aérophile, March, 1938, pages 55–57.

Bomb Attacks on Railway Lines and Stations. D. Mackiewicz. Total disruption of traffic over a given section for a given time, reduction in efficiency of a certain traffic section, destruction of accumulated stores, and demoralization of civilian population are considered. Destruction of a bridge or viaduct is difficult for aircraft both on account of the nature of the target and concentrated defenses. A much better method will be to destroy sections of the line by dive-bombing attack. Attack on railway lines requires special bombs, suitable for both high and low altitude work. Fuses must be capable of various settings, including long delays. For ferro-concrete work, bombs of the order of 1000 kg. will be required. Brief abstract of article translated from Polish to German and appearing in Luftwehr, January, pages 13–17. Jour. Royal Aeronautical Soc., April, 1938, pages 347–348.

Naval Views of the Air. Effect of aircraft on sea communications and on fleet actions. Various opinions expressed on the value of aircraft in "Brassey's Naval Annual" are discussed. Flight, April 21, 1938, pages 378–379.

Rockets for Warfare. A. Ananoff. History, development and future of rockets in time of war. Rev. de l'Armée de l'Air, March, 1938, pages 285–296.

Air Forces

Australia

Australia's Air Defense. It is reported that the Royal Australian Air Force is planning the closest cooperation with the Royal Air Force at Singapore. There are to be combined air exercises to test the defense strategy of Australia's northern approaches. Brief reference.

Australia is converting Darwin into a naval base fit to work in conjunction with Singapore. Personnel of the R.A.A.F. is equal in numbers to the India Command of the R.A.F. and is to be increased by 2780 men. Nine squadrons will be added. Brief note also referring to squadrons up to end of last year. Flight, April 14, 1938, pages 356 and 367.

Australian Expansion. The Australian government will spend an additional £24,800,000 on defense, within the next three years, making a total expenditure, excluding civil aviation, of £43,000,000. First-line aircraft, excluding reserves, would be increased from 96 to 198. Government is communicating with England about deliveries of aircraft and is asking the Commonwealth Aircraft Corporation to prepare for a much larger output than the 40 North American N.A.33s ordered. Quotations from Prime Minister's radio broadcast. Aeroplane, March 30, 1938, pages 377–378.

Canada

Foreign News in Brief. Canadian Department of National Defence has ordered 12 Lysander single-engine two-place aircraft equipped with machine guns and bombing equipment from the National Steel Car Company. Brief reference. Aero Digest, April, 1938, page 86.

The Four Norsemen. Four Norduyn Norsemen high-wing monoplanes have been ordered by the Royal Canadian Air Force for use as flying classrooms. With the 525-hp. Wasp engine, top speed will be about 170 m.p.h. Brief reference. Flight, April 21, 1938, page 385.

R.C.A.F. By the end of the current fiscal year the Royal Canadian Air Force will have in being ten permanent and twelve non-permanent squadrons with a total of 224 airplanes. A number of modern airplanes of R.A.F. design have been ordered from Canadian firms. Defence estimates total £6,800,000. Brief editorial note. Flight, April 14, 1938, page 356.

France

French Production. First prototype of the Morane 405 single-seater fighter, completed over two years ago, was recently crashed by a Lithuanian officer. Second prototype (No. 02) is still not in commission and first production machine is only now doing its tests. The French Air Minister has denied the report that of the 160 aircraft ordered by the French Navy for 1937, only four have been delivered and claimed that 87 had been delivered, although these were said to belong to another order. A number of prototypes are still awaiting their engines. Production of both liquid and aircooled power plants is still behindhand. Brief note. Flight, April 14, 1938, page 368.

Policy of the Air Minister. Construction program calling for 2617 first-line aircraft in 1938. For flying equipment a credit of 9,000,000,000 francs has been earmarked while a grant for personnel, instruction and installations amounts to 6,000,000,000 francs. Principle of the British shadow industry is to be adopted in France. Fixed contracts involving 1810 new aircraft have been placed by the Air Minister. Short note on French Air Minister's program. Interavia, April 23, 1938, page 4.

French Air Rearmament. Present military aircraft production is about 40 a month with about 40,000 employed, while survey claims present production capacity is 140 airplanes a month. French air force piled up 430,000 hours in 1937, 28,000 at night, up about 15 per cent from 1936. The budget has been changed to call for an extra appropriation for the air force amounting to $52,000,000 earmarked for new equipment. Short note. Aviation, April, 1938, page 60.

Great Britain

£11,000,000 for New Stations. Works program of the British Air Ministry provides for the construction of additional Air Force stations and maintenance units distributed throughout England and Scotland at a total cost of nearly £11,000,000 in the coming financial year. Brief reference to this and to a high-altitude practice bombing range which is being constructed at Misson. Flight, April 7, 1938, page 347.

Balloon Barrages. Balloon barrages, designed to keep attacking bombers from sneaking through below 10,000 ft., will soon be ready for London. Most of the material is already delivered and 5000 men unfit for active military service will be recruited to man them. Combined maneuvers at Singapore were announced as proving that base impregnable to attack from any existing foreign bases, but three more squadrons will soon be sent there and there is talk of balloon barrages. Brief references. Aviation, April, 1938, page 60.

Trans-Atlantic Supplies. "It has become known that the United States Government is prepared, if requested, to supply military aeroplanes in large numbers for equipment of the rapidly expanding Royal Air Force." Quotation from one of the British newspapers. Writer of the editorial adds the comment that "We are not yet reduced to buying American 'airplanes' for the R.A.F. There is nothing in the American Air Force better than what we have got in the R.A.F. and there is little as good. Furthermore, we do not hear that there is anything coming along for the American Flying Services which is anything like as good as some things which we know are coming along for the R.A.F." It is suggested that the bigger class bombers be built in Canada, fitted with temporary extra tanks, and flown to England. Aeroplane, April 13, 1938, page 437.

"Combined Exercise." Maneuvers during the Home Fleet's homeward passage from Gibraltar took the form of a convoy exercise, the object being to make a theoretical attack on the Isle of Wight. Objects were carrying-out of air reconnaissance speedily enough to send submarines against a fleet at sea, the exercise of shore-based aircraft in locating and shadowing a fleet, and the attack on a fleet by aircraft and M.T.B.'s. Flight, April 7, 1938, pages 342a–342d, 8 illus.

The Combined Exercises. C. M. McAlery. Account of maneuvers and squadrons and aircraft participating. Aeroplane, April 6, 1938, pages 413–416, 7 illus.

The Fleet Air Arm. Criticisms of the position of the Fleet Air Arm made in the House of Commons March 22 during debate on the Report Stage of the Navy Estimates. Short note. Aeroplane, March 30, 1938, pages 387–388.

More About the Air Estimates. More debate in the House of Commons on March 21, dealing with steel and production, morale of the R.A.F. Short Service officers, Empire defence, wood construction for aircraft, and defense of Scotland and Birmingham. Aeroplane, March 30, 1938, pages 385–386.

More Cadmanising. Quotations from the long second installment of the debate on the Cadman Report in the House of Commons on March 26. A second article contains extracts from the Imperial Airways letter on the Cadman Committee's Report. Aeroplane, April 6, 1938, pages 426–429.

Status of the British Air Force. Status of the British Air Force in regard to aircraft on January, 1938 (169 squadrons), and January, 1935 (91 squadrons). Present strength of the local air force is given as 420 fighters, 840 bombers, 120 cooperation, and 162 flying boats and coastal scouting aircraft. Strength of the Fleet Air Arm is 217 aircraft. Number of aircraft located at Aden, Middle East, India, Malta, Iraq, Palestine and Far East are also given (total 272 aircraft). Total for entire force is 2031 aircraft. Short note. Luftwehr, February, 1938, page 58, 1 table.

A Veteran Reserve for the R.A.F. Royal Air Force Ex-Officers' Emergency Reserve has recently been formed as an additional reserve for the R.A.F. It consists of those who held commissioned rank in the Air Services during the War 1914–18 and since, but who are no longer on the Active List, or in any branch of the Reserve, or liable to recall because they are on the Retired List. Potential strength calculated is about 42,000. Long discussion. Aeroplane, March 30, 1938, page 383.

HOLLAND

The Dutch Dorniers. Eighteen Dornier Do-24K flying boats (three Wright Cyclones) will be built under license in Holland. Twenty-four are to be built at the Friedrichshafen works and two have already gone out to the Dutch East Indies. Brief reference. Flight, March 31, 1938, page 324.

ITALY

M. Mussolini on Italian Aviation. Around 58,000 workers are engaged in the production of aircraft and engines in Italy. "The attention of our engineers is directed to equipment which can be used for reconnaissance, bombardment and defense. . . Our C.R.-32s in the Spanish skies have brought down quantities of Curtiss and Rata airplanes of higher speed. The bimotor is for reconnaissance and light bombardment, but for long-range bombardment and heavy load the tri-motored airplane is necessary. We have a type which is particularly envied and in demand. The four-motored aircraft can be used in civil aviation." Quotations from a recent speech by Mussolini. Les Ailes, April 14, 1938, page 6.

The Wing. Newly formed Italian unit "Squadra Aerea" is an extraordinarily mobile large combat formation and is free from all duties of ground service as far as possible. Air Zones will look after the ground services, such as supply of fuel, armament, and munitions for the Squadra, but they will have no supervision over the services and exercises of the formation. Number and stationing of the Squadra depend on strategical considerations. Short note. Interavia, April 23, 1938, page 16.

JAPAN

Japan's Aeronautical Research. All-around aeronautical research institute proposed should be equipped to enable Japan to do its own researches and development work. "When completed the organization is expected to excel the research establishments of the R.A.E., N.A.C.A., D.V.L. and French S.T.A." Brief note. Aeroplane, March 30, 1938, page 392.

Military Aviation. A Japanese aviation mission will leave soon for Siam and certain members will undertake the development of airports. Two hundred Siamese officers will be initiated into certain Japanese air forces.

From the beginning of hostilities up to December 10, 1937, the naval aviation force have dropped about 1060 tons of bombs in central and Southern China and a total of 6230 aircraft have taken part in the bombing raids. Up to December 31, 578 Chinese aircraft had been destroyed, of which 258 airplanes crashed during air combats and 320 were destroyed on the ground. During the same period 63 Japanese naval airplanes were lost. Short note. L'Aérophile, February, 1938, page 28.

PORTUGAL

Reorganization of Portuguese Aviation. Junkers Ju-52 night bomber, Ju-86 day bomber, Breda 65 for bombardment and reconnaissance, and the Gloster Gladiator fighter have been bought for the air force. Note on the reorganization of military and civil aviation. Les Ailes, April 14, 1938, page 6.

U. S. A.

Our Air Defenses Gain in Efficiencies. Army and Navy aviation statistics for 1933, 1935, 1937 are shown in diagrams for airplanes on hand, total aviation personnel and air appropriations. Map shows bombing range of the European countries from London and map of the United States and Pacific Ocean is given to indicate our vulnerability when range of bombers increases. Editorial points out our technical superiority and urges that Army and Navy strength be increased.

Other articles indicate in diagrams: amounts paid during 1937 for the various phases of private, commercial and military aviation, and for engines and aircraft; airline statistics and sums spent; private-flyer statistics; and production 1929 to 1938. A map showing airlines of the world is included. Aviation, April, 1938, pages 20–31, many illustrations.

U.S. Dive Bombers. "Today, when several Air Arms are openly questioning the practicability of the steep diving attack, the U.S. Navy is taking into service large batches of dive-bombing machines to augment the squadrons of Vought and Great Lakes biplanes already used for the work." Brief references are made to the Curtiss SBC-3, Northrop BT-2, and the experimental mid-wing Brewster. The standard bomb load is said to be either a 500-lb. or 1000-lb. bomb. Flight, April 21, 1938, page 385.

Fundamentals of Air Warfare in Soviet Russia. Part II deals with the use of fighter airplanes in Soviet Russia and covers: tactical superiority of fighters; their use in air combat on their own and enemy territory and in attack on the air depots and supply stations; duties of various types of fighter airplanes including the single-seater, two-seater, and multi-seater; cooperation of fighters and other types of aircraft; scouting for the air force; cooperation of light bombers with fighters; cooperation in ground attack; assistance to army scouting airplanes; troop carriers with fighters; fighters as liason airplanes; and ground and commanding organizations.

Part III is devoted to the cooperation of light bombers, fighters, and ground attack airplanes with army troops and discusses: duties of each of these airplanes, their participation in combat with ground troops, attack on a defensive opponent and fighting under special conditions. Concluded. Luftwehr, February, 1938, pages 42–46.

Future Soviet Construction. When the Soviet factories have finished turning out American-designed Vultee V-11 attack bombers it is said that they will build under license the Potez 63 bomber-fighters, Hanriot 220 twin-engined two-seater fighters, Boeing YB-17 heavy bomber, and a twin-engined Curtiss bomber, presumably similar to the A-18 attack airplane. Consolidated twin-engined monoplane flying boats may also be built. Brief reference to rumor. Flight, April 14, 1938, page 368.

The Principles of Aerial Warfare in U. S. S. R. Suitable flight formations of heavy bombers usually operating in formation and intended for attack on targets well inside enemy territory. Object of the formation is to give mutual fire support and this may entail rapid changes depending on method and direction of attack. In aerial combat it will always be the object of either side to maneuver the opponent into a position which reduces the effectiveness of his fire. Examples of such maneuvers are given. Very brief abstract of article translated from Russian to German and appearing in Luftwehr January, pages 2–8. Jour. Royal Aeronautical Soc., April, 1938, page 347.

Technical Crisis in Soviet Aviation. Soviet policy to acquire licenses to build foreign aircraft in U. S. S. R. is said to indicate the actual disorganization of Soviet equipment. They are beginning to build in large series the Vultee single-engined bomber, and licenses have been purchased to build the Curtiss bimotored fighter, Potez 63 and Hanriot 220 bimotored plane. Question of acquiring the license to build the Boeing four-engined bomber in U. S. S. R. is referred to. Brief note. Les Ailes, March 24, 1938, page 6.

Armament

Armament of Ground-Attack Airplanes. Capt. N. J. Schaurow. Arrangement of machine guns of the ground-attack airplane for firing in the horizontal plane (guns firing to the front from wing positions). Firing distance which must be considered in attack with airplanes, size of the diameter of the dispersion area of the machine gun and machine-gun batteries, and the combined distances of machine-gun batteries installed in airplanes are discussed. Lateral dispersion in the case of three airplanes flying in close formation of not more than 5 meters distance is also considered in regard to range of fire, width of lateral dispersion of the separate airplanes of the group, width of the airplane, and spacing of the airplane in the group. Conclusion of German translation from "Wjestnik wosduschnowo flota," October, 1937.

Editor in a note commenting on the article states that to his knowledge a ground-attack airplane introduced into the Soviet Air Force has four rigidly-installed machine guns directed downward at an angle of 45°. Also the LSCH ground-attack airplane used in the Spanish Civil War on the side of the Loyalists has rigidly-installed machine guns directed downward at an angle. Luftwehr, February, 1938, pages 48–50, 9 illus.

Armament for Air Cruiser and Counter-Cruiser Airplanes. Brissot, Chief Engineer of Aeronautics. Defensive armament for airplanes designated as "air cruisers" which are required to penetrate very far into the interior of enemy territory with the intention of attacking that territory. Offensive armament for "counter-cruisers" used to attack the air cruisers is also taken up. Discussion of the defensive armament necessary for the air cruiser covers total field of fire, firing stations, distribution of the total field of fire between three stations, equipment for the different firing stations, and number and types of arms for each firing station. Advantages of fixed artillery for the offensive armament of the counter-cruiser, types of arms employed, direction of fire, and the case of the multiplace counter-cruiser are considered. Rev. de l'Armée de l'Air, March, 1938, pages 269–284.

The Machine Gun Installation on Ground Attack Aircraft. N. J. Schaurov. Until quite recently machine guns in aircraft intended for ground attack were mounted parallel to the longitudinal axis of the aircraft. Before the attack the aircraft had to climb to a certain altitude and firing of guns was carried out at relatively low altitude while the aircraft was diving towards the target. With modern highspeed aircraft it will be possible for the aircraft to fly on a parallel course above the target without being in any great danger of a hit. Ground attack under these conditions can be carried out by having the machine guns mounted so that they are permanently inclined downwards at a small angle. This method has the advantage that a number of aircraft can cooperate without danger of collision.

Very brief English abstract of first installment of article translated from Russian into German and appearing in Luftwehr, January. pages 10–13. Jour. Royal Aeronautical Soc., April, 1938, page 347.